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THE

STEAM NAVY OF ENGLAND:

PAST, PRESENT, AND FUTURE.

BY

HARRY WILLIAMS,

CHIEF INSPECTOR OF MACHINERY, ROYAL NAVY.

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TO

ADMIRAL HIS ROYAL HIGHNESS

THE

DUKE OF EDINBURGH,

K.G., K.T., K.P., ETC., ETC.

PREFACE.

It may be thought by some that the title of this book is somewhat misleading: "The Steam Navy of England: Past, Present, and Future"; but really it indicates with some accuracy the scope and tenour of the contents. For while the facts recorded are essentially those of the present time, unavoidable reference, for purposes of comparison, is frequently made to the past, and in this way the past and present are linked together.

But the chief aim throughout has been to keep steadily in view the possible requirements of the *future* Navy, and to do this it is necessary to consider the many great changes made during the past fifty years, the change still going on, the stage of transition reached, its further development, and, as far as can be ascertained by enquiry and deduction, the Navy's final form. From this we shall be able to approximately forecast what provision it would be well to make to meet the full requirements of our future Navy.

On this subject, of primary importance to the nation, there is sure to be great diversity of opinion among admittedly able men. To take a single subject: Some will boldly advocate a radical change in the war-training of our seamen, the present system being obsolete in these days of mastless war-ships, when the old seamanship of the time of the wooden men-of-war appears to be abandoned. Others will favour a middle course, a policy of compromise; and some will take the old Navy view, that the training of the men on the old lines is sufficient, having produced good men in the past, which is all that is wanted now.

Considering that the present Navy is altogether unlike that of the past, what is wanted is to endeavour to ascertain what measures should be adopted for meeting the requirements caused by the altered conditions; and the discussion of the several important points raised for consideration will, it is hoped, enable many to come to some decision on the subject.

Perhaps it would be well to briefly enumerate some of the principal changes made during the past fifty years. The material of which ships of war are built has been changed from wood to iron, and from iron to steel; modern ships are of a different type to those of the old Navy, being now made with a view to their being efficient portable floating batteries; armaments of ships have been changed to an extent almost incredible; propulsion by sail-power has been almost abandoned, and that by steam-power substituted; and,

whereas in early days steam-power was chiefly auxiliary, it is now the sole motive power on which depends principally the fighting, and wholly the manœuvring power of modern war-ships.

But it seems to require something more than this to bring home vividly to our minds, not only the magnitude of these changes, but the marvellously short time in which they have been made. This might he done by the statement of a well-known event in naval history, the truth of which can be vouched for by the Author, because he was present, viz., that in 1854, *only thirty-eight years ago,* two English and French fleets, acting in combination, fought an action with the forts and batteries, defending the approaches to Sebastopol in the Black Sea, and that these two large fleets of war-ships were composed *entirely of wooden vessels,* some of which were *sailing line of battle-ships.*

Thus it will be seen that practically the reconstruction of the Navy has taken place during the past forty years, and the fact is noted, because it has a bearing on the subject-matter of this book, and should not be lost sight of when considering the several points raised for discussion.

As has already been remarked, it is the chief aim of the Author to submit his views of the points considered, in the hope that the discussion of them may result in the adoption of the best means for promoting the efficiency of the present and future Steam Navy of England.

It should be added, that five of the chapters of this book have appeared as articles, from time to time, in the leading Service journal, the "United Service Magazine."

H. W.

Devonport, September, 1892.

CONTENTS.

PART I.

PART II.

PART III.

PART IV.

SYNOPSIS OF CONTENTS.

PART I.

OUR SEAMEN.

CHAPTER I.

ON INCREASING THE FIGHTING POWER IN SHIPS OF WAR BY TRAINING NON-COMBATANTS IN COMBATANT DUTIES.

CHAPTER II.

THE GENERAL WAR TRAINING OF THE NAVY.

CHAPTER III.

THE TRAINING OF OUR SEAMEN.

PART II.

SHIPS AND MACHINERY.

CHAPTER I.

Forced Draught in Boilers of War-ships.

PAGE

from simple to compound, and from compound to triple expansion—Necessitating the use of very high pressure steam, and the manufacture of boilers capable of bearing safely the greater strain due to the higher pressure—Abolition of sail-power in modern battle-ships and cruisers—Results: lessening the weight carried and giving increased flotation, but neutralised by increased weight of armament; heavy protective plating; more auxiliary steam machinery; duplication of propelling engines; and the necessity for great coal-carrying capacity—To meet this: weight of engines and boilers reduced, the latter to too great an extent—Forced draught: description—Definition of excessive forced draught, and limited forced draught—Use of excessive forced draught unsafe, as proved by very numerous breakdowns of new boilers under the strain—A limited and safe forced draught suggested—Reasons for this limitation—Illustrations of the result as to speed of vessel and development of engine-power, of the use of the excessive and the limited forced draught—No instances on record of the failure of new boilers by the use of a purely natural draught—Nature of injury done to boilers by the use of an excessive forced draught—What causes this injury? Full discussion and explanation in detail—Traced to imperfect contact between the water and the heating surface of plates and tubes. What should be done with the large number of ships in which the excessive forced draught must be used to get the maximum contract engine-power?—What measures to adopt in future ships to ensure that the maximum contract power and speed should be obtained as regards the boilers under safe conditions—What constitutes an ideally perfect ship of war?—That the four grand divisions into which every ship can be divided are each up to an equally

CHAPTER II.

INDUCED DRAUGHT v. FORCED DRAUGHT IN BOILERS.

CHAPTER III.

FURTHER REMARKS ON FORCED AND INDUCED DRAUGHT IN BOILERS OF WAR-SHIPS.

CHAPTER IV.

Modern Marine Engines.

PART III.

NAVAL ENGINEERING.

CHAPTER I.

NAVAL ENGINEERING IN WAR-SHIPS.

CHAPTER II.

Naval Engineering in War-ships—continued.

machinery generally in an efficient condition without assistance from dockyards except by supplies of material—Reasons why engineer officers and dockyard officials will probably disapprove of the proposition—Objections met by considering the circumstances under which all ships are commissioned and the service performed during commission—Conditions imperatively necessary for the carrying out of this great work—Time and opportunity for making examinations and timely repairs—And the provision of an efficient engine-room staff—Incidental reference to the reduction of the number and the lowering of the quality of the mechanic staff of the ships, lately ordered to be carried into effect by the Admiralty—Author's experience for nearly forty years: always supported and assisted by captains in maintaining the efficiency of the machinery by the ship's staff—Limits to the proposition considered—Heavy breakages must be made good by dockyards—But such breakages can be, generally speaking, prevented by careful management—Instances of occasions on which machinery defects lists have been sent in when quite unnecessary—Chiefly in accordance with a bad old custom—This should be discouraged for many reasons—Appeal to officers to keep their ships efficient by the fleet officers and men—Can the fleet mechanic ratings be improved and made more fit to carry out this great work?—Definite plan proposed—Using the Steam Reserves as a means of improving the mechanical ability of the fleet men—The necessary appliances in the Reserves: large workshops; all kinds of machines worked by steam-engines; smitheries; foundries—Opinions of dockyard officials adverse to the extension of Steam Reserve work considered; reasons for discounting the value of their opinions—Efficiency of our fleet of paramount importance—Dockyards only useful in so far as they promote

CHAPTER III.

NAVAL ENGINEERING IN WAR-SHIPS—CONTINUED.

CHAPTER IV.

NAVAL ENGINEERING IN WAR-SHIPS—CONTINUED.

PART IV.

MISCELLANEOUS.

CHAPTER I.

THE COAL ENDURANCE OF HER MAJESTY'S SHIPS.

A.—SINGLE SHIPS OF WAR.

CHAPTER II.

ON THE ENGINE-ROOM COMPLEMENTS OF HER MAJESTY'S SHIPS.

CHAPTER III.

Remarks on Electric Lighting and other Subjects.

Harry Williams

PART I.

OUR SEAMEN.

THE STEAM NAVY OF ENGLAND.

CHAPTER I.

ON INCREASING THE FIGHTING POWER IN SHIPS OF WAR, BY TRAINING NON-COMBATANTS IN COMBATANT DUTIES.

Non-combatants serving in war-ships—Varying from 27 to 40 per cent.—Serious deficiency of fighting power resulting from this—Causes of the great increase in the number of non-combatants during the past thirty years—Can the majority of these men be trained in combatant duties?—Scheme for training over 12,000 of them into skilled gunners, with no expense for instruction, no loss of efficiency as regards their special duties, and no interruption of the general service of the Fleet—Four special rules to be observed to make the operation of the scheme successful—Several possible objections considered—Two battle-ships, *Anson* and *Edinburgh*, taken as illustrations to show the results of the scheme, after it had been in operation a sufficient time to produce its full effect—Estimated total increase in the fighting and steaming power in the Navy, due to the operation of the scheme - Beneficial effect of the scheme in adding large contingents of highly-trained fighting men to the reserve, available in time of emergency to assist in manning Her Majesty's ships—Conclusion.

IN all ships in commission there is a number of men who are non-combatants, forming no part of the skilled fighting power in Her Majesty's fleet.

These men form 27 per cent. of the ship's crew in small vessels of the *Lapwing* class, and no less than 41 per cent. in the *Anson-Admiral* class, our

largest battle-ships. For some time past the number of these men serving in men-of-war has been increasing, and the seamen combatant ratings diminishing in like proportion. This has been caused, 1st. By steam having largely superseded sail power in the battle-ships and cruisers; and 2nd. By the work formerly done in our ships by manual labour being to a very great extent done now by steam machinery.

Thus, in view of the diminution of the fighting element in our ships' crews, it has become a serious question, how the large number of non-combatants can be reduced by most of them being trained into combatants.

Of these men much the most numerous class are the stokers of various ratings, numbering several thousands, and forming about 60 per cent. of all the non-combatants of the Navy, the others being made up of blacksmiths, carpenters' crews, stewards and cooks, and ships' artificers generally.

It is proposed to show in this chapter how these thousands of non-combatant stokers could be trained into skilled gunners, with no expense to the country in respect of an instructional staff, and with no loss of efficiency as regards their special duties as stokers.

To carry out this scheme it will be necessary on commissioning a ship to draft to her a number of stoker ratings in addition to the present complement, so that the total number shall be divisible into four nearly equal parts, three of which will be the present sea-going complement.

Of this total number, it is proposed that three-

fourths—equal to the present sea-going complement—shall be employed in the engine-room department, and the remaining fourth on deck, for the performance of general deck duties, but specially with a view to being trained as combatants.

In order that all leading stokers and stokers shall receive this training, it is proposed to change the deck parties in such a way that in four months every one of these men in the ship shall do duty in the engine-room department for three months, and on deck for one month. It is distinctly to be understood that the deck party of stokers for the time being shall be exclusively employed in the performance of deck duties, and entirely away from the control of the engineer officers.

To do this it will be necessary to make four lists of names, called the A, B, C, and D lists respectively, each list to comprise, as nearly as possible, one-fourth of the total number of the stoker class drafted to the ship on commissioning.

In explanation of the manner in which the deck party of stokers should be changed monthly, two statements are annexed, marked 1 and 2, by which it will be seen that H.M.S. *Anson* has been taken as a typical ship for explaining the method.

Statement 1 shows the present sea-going complement; the proposed addition to this; and the total number divided into four nearly equal parts in A, B, C, and D lists.

STATEMENT 1.—Explaining a scheme for training stoker ratings in combatant duties.

Showing the the total number of leading stokers,

and 1st and 2nd class stokers, in four nearly equal parts, A, B, C, and D lists.

		Leading Stokers.		1st and 2nd Class Stokers.
Present sea-going complement	...	16	...	93
Proposed addition ...	...	5	...	31
Total number	...	21	...	124

Total number divided into A, B, C, and D lists :—

A list will comprise	...	...	5	...	31
B " "	...	...	6	...	31
C " "	...	...	5	...	31
D " "	...	...	5	...	31
Total number		...	21	...	124

H.M.S. *Anson*, 1st class battle-ship, 10,600 tons, 11,500 h.p., has been taken as a typical ship.

STATEMENT 2.—Explaining a scheme for training stoker in combatant duties.

This statement shows the method of arranging the stokers into deck and engine-room parties, and of changing the deck parties every month.

H.M.S. *Anson*, 1st class battle-ship, 10,600 tons, 11,500 h.p., has been taken as a typical ship.

Month.	Deck Party.	Leading Stokers.	1st and 2nd Class Stokers.	Engine-Room Party.	Leading Stokers.	1st and 2nd Class Stokers.
Jan. -	A List, comprising	5	31	B C D Lists, comprising	16	93
Feb. -	B List, comprising	6	31	A C D Lists, comprising	15	93
March -	C List, comprising	5	31	A B D Lists, comprising	16	93
April -	D List, comprising	5	31	A B C Lists, comprising	16	93

NOTE.—It is assumed that the ship is commissioned in January: Routine of the first four months will be repeated during the commission. No alteration should be made in lists of names unless absolutely necessary.

Statement 2 shows the arrangement for changing the deck parties every month, for the first four months of the commission. Commencing with January, the changes would be as follows :—

		Deck Party.		Engine-Room Party.
January	...	A List	...	B C D Lists.
February	...	B List	...	A C D Lists.
March	...	C List	...	A B D Lists.
April	...	D List	...	A B C Lists.

And these monthly changes would be repeated for the remainder of the commission.

In connection with the changing of the deck parties, it may be remarked that there should be no difficulty in the two parties changing from the deck to the engine-room, and *vice versa*, taking over stations and duties.

In order to be able to draft additional stoker ratings to ships commissioning, it will be necessary to gradually strengthen the Steam Reserves, and there is no doubt that this plan, if carried out, will necessitate an increase of over 20 per cent. of the stokers now in H.M.'s service.

This increase in the number of stokers appears to involve additional annual expenditure, but as, by the plan, the whole of these additional men will, in all commissioned ships, be exclusively employed in the performance of deck duties, it is probable that a decrease in the number of men who now perform these duties could be made, and for this reason it is not anticipated that the adoption of this plan would cause much additional expense.

It may be remarked in connection with the question

of expense, that the actual training in combatant duties of this large number of men will not entail any additional cost, since there will always be in every commissioned ship competent men to give the necessary instruction.

Chief stokers are left out in the scheme, because by its operation they will have become highly-trained men while passing through the lower stoker ratings.

The education and training of all stokers in H.M.'s fleet in combatant duties, without lessening their efficiency as stokers, could, it is considered, be done by the plan proposed, and, considering the importance of the end in view, at a moderate cost. It is not expected that the great work of training in gunnery so large a number of men can be effected in a short time, in six months, or even a year; but it is probable that, under the operation of the plan, a stoker of moderate intelligence would, by the end of his first commission, obtain a good amount of skill in gunnery, and become a good stoker, and would go on from that point and rapidly become a highly-trained man.

The majority of stokers serve for twenty-two years. On entry into the Service they spend an average time of six months in a steam reserve, and during that time are taught the rough part of stoking, and cutlass, rifle, and other drills in the guard-ships. They are then drafted into commissioned ships, and continue to serve either in commissioned ships or in the steam reserves for the remainder of their time.

As, therefore, a stoker would obtain a good amount of skill in gunnery and stoking by the end of his first

commission, viz., four years from entry, he would be a trained man as a stoker and gunner for the remainder of his time, *i.e.*, for eighteen years.

To make this plan thoroughly successful it is strongly recommended—

1. That it be carried out in its entirety. No leading stokers or stokers should be exempt from its operation. The object is that all stoker ratings shall be made experts both as gunners and stokers.
2. That the action of the plan be continuous. Whether the ship be in harbour or at sea the interchanges should be made at the prescribed intervals, and the duties carried on without break. Also that, after the men have been trained, the plan should still be operative up to the time of discharge, or rating as chief stoker, in order that exercise and practice might produce greater expertness.
3. That special attention be given to all stokers serving their first commission after entry, with a view to their receiving as much instruction in gunnery as possible during the monthly intervals on deck.
4. That notations be made on the parchment certificates of the progress made in gunnery, &c., &c., and that the men be informed that these notations will be considered when men are selected for advancement to the ratings of leading and chief stokers.

With reference to the fourth recommendation, it may

be observed that the leading stokers would be the leaders of the lower ratings, whether employed on deck or in the engine-room; that the same intelligence which would make an efficient stoker would probably make a good gunner; and that a knowledge that early efficiency in gunnery would weigh in a stoker's favour for rating as leading stoker would produce a spirit of emulation among the men which would conduce to their more quickly becoming competent both as gunners and stokers.

I will now consider some objections that might be urged against the proposed plan for training the stokers into skilled combatants.

First Objection. The employment of the stokers on deck for a limited time would perhaps make them less efficient as stokers. As this is a serious objection it will be necessary to deal with it fully. Sailing has been almost entirely superseded by steam-power, and the increased amount of steaming now compared with that formerly has very much increased the efficiency of the naval stokers, and I am of opinion that the adoption of the plan will not lessen this efficiency. My opinion is founded on the following statements.

In the case of new ships, though the large engine makers, at the contractors' steam trials, had by the Regulations the option of employing skilled stokers from the mercantile marine or elsewhere, yet during the four years I served in the Devonport Steam Reserve the Service stokers were always preferred, presumably because they could get more out of the boilers than any other class of men.

A marked instance of this occurred two or three years ago. A premium was offered to the engine makers of a new class of ship for every indicated horse-power developed above the contract. The excess of horse-power, and the pecuniary benefit derivable therefrom, would depend in a great measure on the efficiency of the stoking. Under these circumstances the contractors chose the Service stokers in preference to any others.

When it is considered that the contractors' steam trials are of the greatest importance to the engine makers, that on the success of these trials depends whether the machinery will be received by the Admiralty at the contract price, that to be successful the contract indicated horse-power must be developed, and that the development of this power largely depends on the excellence of the stoking, it is evident that no higher tribute could be paid to the naval stokers than the choice of them by the contractors to carry out their steam trials in preference to any skilled men obtainable elsewhere.

It is therefore considered that the employment of the stokers for a limited time on deck, as proposed by the plan, would not impair their efficiency as stokers.

Second Objection. The substitution of a small number of stokers in every commissioned ship for as many seamen would reduce the number of the latter below the requirements as regards seamen's duties.

To this it is answered—first, the number of stokers substituted for seamen would be so small *in each ship* as not to have this effect. Secondly, these stokers would be exclusively employed during their month in

deck duties, and would, therefore, be available to do the duty of the seaman they would be substituted for.

Third Objection. Seamen and stokers would be more efficient as gunners and stokers if they were *always* employed in their respective departments.

To this it is answered, that the question is, not whether the men would be more efficient if always employed in their respective departments, but whether, in our ships of war, with numerically small crews as compared with former days, a large number of men could not be trained to be both stokers and gunners, and thereby increase the fighting and steaming power of the ships *without addition to the present complements.*

Fourth Objection. Stokers are slightly better paid than seamen of the same ratings, therefore the substitution of a number of stokers for as many seamen as proposed would cause additional expense.

The answer to this is that the total number of stokers substituted for seamen would probably be something over one thousand; that these men would be taught gunnery on board the commissioned ships in which they were serving (for every one of these ships would be an instructional school for this training), and that the utilisation of the instructional element on board these ships would render unnecessary the expensive training of the seamen for whom the stokers would be substituted. On the whole it is considered that, under the proposed plan, the training of the stokers would, man for man, be less expensive than the present training of the seamen, even taking into account the slightly higher pay of the stokers.

In this connection it should not be forgotten that the services of the stoker, trained both in gunnery and stoking, would be of much more value to the Service than the present man skilled in only one thing.

Having dealt with possible objections, I will now give an illustration or two, showing the results of the proposed plan, after it had been in operation a sufficient time to produce its full effect.

Taking the case of the *Anson*. (See Statement 1, pp. 5-6.) At present there are 109 of the stoker class who do not understand gunnery, and a number of seamen who cannot do stoking. By the proposed plan the 109 would be trained and become gunners as well as stokers, and the 36 men who would replace seamen would be stokers as well as gunners.

Thus there would be in the *Anson* 145 men who would be both stokers and gunners, in place of—as at present—109 men who cannot fight the guns, and 36 seamen who cannot stoke the fires.

Similarly in the case of the *Edinburgh* there would be 114 men, both stokers and gunners, in place of—as at present—86 stokers who cannot fight the guns, and 28 seamen who cannot do stoking.

Having dealt with two cases of single ships of war, I will now show what the probable effect would be as regards the gross number of men affected by the proposed plan, still supposing it to have been in operation a sufficient time to have its full effect.

Assuming that the present number of sea-going men of the stoker class serving in *commissioned* ships is 4,200, it follows that, by the plan, 1,400 stokers would

be added, being substituted for as many seamen, and that the total number would be 5,600 trained both in stoking and gunnery.

Thus there would be a material increase both in the fighting and steaming power in the Navy

This increase might be represented as follows :—

1. Number of men—stoker class—available in the fleet as gunners (an addition to the present number of gunners) -	4,200
2. Number of men—stokers in place of as many seamen—available in the fleet as stokers (an addition to the present number of stokers) - - - -	1,400
Total	5,600

And these 5,600 men would be interchangeable as regards stoking and gunnery, being competent to perform both duties.

From the above it will be seen, by 1, that the 4,200 men will represent the increase of the fighting power; and, by 2, that the 1,400 men will represent the increase of the steaming power in the Navy as the results of the proposed plan, results obtained with no addition to the number of men now employed in Her Majesty's fleet.

If, however, it should be considered undesirable to reduce the number of seamen now drafted to ships on commissioning, it would not affect the plan of training the stokers in gunnery; but the 1,400 stokers would not be *in place of* as many seamen, but *in addition to*

the number now in the Service. This, of course, would cause increased expense ; but as a set off to this the Navy would have the benefit of the valuable services of the 1,400 highly-trained men.

Another most important result of the operation of this plan would be that a number of these highly-trained men would, at the age of forty-five, be continually going on the pension list, and these pensioners would form a valuable reserve of competent men, who might be called on to assist in manning Her Majesty's ships in time of emergency.

It may here be asked, why should not all the non-fighting men, *e.g.*, carpenters, blacksmiths, &c., &c., be also taught gunnery ? This is not necessary, because, first, the stoker class being much the most numerous of the non-combatant men, probably 60 per cent., it is considered that, if they be trained as gunners, the fighting element of the Service will be amply sufficient for all requirements ; second, when a ship is in action there is much work to be done which can be done by non-combatants, and these can be usefully employed in doing this work.

At present our ships of war go to sea with crews just numerically sufficient for the requirements, with but little reserve. Not only so, but these crews are made up of specialists, men who can do *only one thing well.* This being so, should not an attempt be made to train a large portion of these crews into all-round men, men competent alike to stoke the fires, attend the machinery, and fight the guns ?

In the foregoing remarks the number of men dealt

with are those who are actually serving in *commissioned sea-going* ships, viz., 4,200; but it is evident that the adoption of the scheme would, in the end, bring under its operation the whole of the stoker class in the Navy. Two years ago these men numbered nearly 10,000, and since then large additional entries have been made. Probably the total number of stokers, of all ratings, at present in the Navy cannot be less than 12,000, all of whom, except a small number of chief stokers, would come under the operation of the scheme; the effect being that nearly 12,000 men (stokers) would be added to the combatant ratings of the Navy, and there would be a corresponding decrease in the non-combatants now forming a large proportion of the complements of all sea-going ships of war.

Assuming that all men of the stoker class—except chief stokers—would, in the end, become combatants, and that the number in the Navy is at present 12,000, it will be seen by a reference to the proposed scheme in the foregoing pages, that the number to be added would be 4,000, making the total number affected 16,000; and another statement will be required to correctly represent the ultimate increase of the fighting and steaming power of the Navy by the adoption of the scheme. Now, assuming it to have been in operation a sufficient time to have had its full effect this statement would be as follows:—

1. Number of men—stoker class—available in the fleet as *gunners* (an addition to the present number of gunners) - 12,000
2. Number of men—stokers in place of as

many seamen—available in the fleet as *stokers* (an addition to the present number of stokers) - - - - - 4,000

Total number 16,000

And these 16,000 men would be interchangeable as regards stoking and gunnery, being competent to perform both duties.

From this last statement it will be seen, by 1, that the 12,000 men will represent the increase of the fighting power; and, by 2, that the 4,000 men will represent the increase of the steaming power of the Navy, as the results of the proposed scheme, results obtained with no addition to the aggregate number of men now employed in Her Majesty's fleet.

It is necessary to repeat here, that should it be considered undesirable to reduce the number of *seamen* now drafted to ships on commissioning, it would not affect the scheme for training the stokers in gunnery; but the 4,000 stokers (2) would not be *in place of* as many seamen, but *in addition to* the number now in the Service. This, of course, would cause increased expense, but as a set off the Navy would have the benefit of the services of the 4,000 highly-trained men.

A point of the greatest importance must here be considered in connection with the successful carrying out of the scheme, viz., that no *complete success* can be looked for unless instruction in gunnery be the principal object aimed at; the performance of other deck duties being, though of considerable, yet of minor importance. We may repeat here what is laid down in

the foregoing pages, viz., that to make the scheme quite successful it will be necessary to carry it out in its entirety.

"None of the stoker class, except chief stokers, should be exempt from its operation. The object is that all stoker ratings shall be made experts both as *gunners* and *stokers*."

The rigid observance of this rule is absolutely essential to complete success.

It may be mentioned here that though no definite scheme—except that contained in the foregoing pages—for the training of the stokers in gunnery has ever been proposed or formulated; yet some of our most able naval officers have expressed very decided opinions that the stokers should be *so* trained. Of these, Admiral Sir Edmund Robert Fremantle* and Captain C. C. P. FitzGerald, R.N.,† are two, and there are many others; but the latter considers that the stoker when rated P.O. should no longer go with his watch of men to receive the monthly instruction in gunnery on deck. As to this, it should be remembered that my scheme applies only to the single plan of training our 12,000 stokers in gunnery, to be gunners as well as stokers. When, however, we attain to that ideal condition of things, which Captain FitzGerald wishes for, and apparently looks forward to, viz., that the general service men of all classes and ratings, seamen as well

* Lecture on "The Training of our Seamen," by Vice-Admiral the Hon. Sir Edmund R. Fremantle, K.C.B., C.M.G., R.N. *Journal of the Royal United Service Institution*, March, 1892.

† "War Training of the Navy," by Captain C. C. P. FitzGerald, R.N. *United Service Magazine*, April, 1891.

as stokers, shall be so trained as to be interchangeable, able to work on deck or below, in the engine-room or any other part of the ship;* when we reach this ideal condition of things, I quite agree with Captain FitzGerald and Mr. Edwards in this matter, viz., that men should be promoted in that line in which during their all-round training they had shown special aptitude, and that when so advanced they should be retained in that department. "If a man be a better gunner than stoker he should be made captain of a gun; if a better stoker than gunner, he should be kept to fill the rating of leading stoker . . . . . and when made petty officers, men should be retained in their particular department."† Captain FitzGerald evidently has in view the training of all the lower ratings in general service as all-round men. For a definite plan for carrying out this important work, see next chapter, which contains the only plan for doing this yet placed before the public.

In conclusion: The scheme for training the large number of stokers into skilled gunners is submitted for consideration. Its adoption would not entail much additional expense; would require but little change in the general routine carried out in commissioned ships; would be automatic in its action; and, without adding materially to the complements of our ships, or to the total number of men in the Navy, would convert no

* A definite plan for carrying out this is formulated in the next chapter.

† *Vide* February (1891) number of the Royal United Service Institution. Speech of Mr. R. W. Edwards, Chief Engineer, R.N., on "Training of Seamen."

fewer than 16,000 non-combatants into skilled fighting men, and, by thus greatly increasing the reserve of fighting power in Her Majesty's ships of war, add materially to the strength and efficiency of the British Navy.

CHAPTER II.

THE GENERAL WAR TRAINING OF THE NAVY.

In view of the great changes in material, build, rig, tonnage, armament, and engine-power which have been made in our war-ships during the past forty years, should there not be a corresponding change in the training of our seamen, to make them fit in with the altered conditions?—Should not this change in the training be directed to making our seamen *all-round* men, able to work on deck, between decks, below in the engine-rooms and stoke-holds, and in boats?—Plan in detail for effecting this—Tabular statement showing the result of this training—Possible objections to the plan considered—Duties of seamen of the past and future contrasted—Should not the training of seamen of all classes in future have for its primary object the making them competent to perform the duties appertaining to modern seamanship?—Appeal for the suggestions to be considered without prejudice, because of the end in view, viz., increase of naval efficiency.

IN the last chapter I endeavoured to show how all men of the stoker class, non-combatants, now numbering about 12,000, might be trained in gunnery with no loss of efficiency as regards their special duties as stokers. These men amount to between 60 and 70 per cent. of all the non-combatants of the Navy, and they have become so large a proportion of the complements of commissioned ships of war, that they form from 27 to 40 per cent. of every ship's crew. These men add nothing to the skilled fighting power of the ships, and with a view to their contributing in some measure to this fighting power a scheme is formulated

in the last chapter, which, if adopted, would convert this large number of non-fighting men into skilled gunners. This would reduce the large and increasing proportion of non-combatants who now serve in our sea-going war-ships.

But this chapter will be devoted to the consideration of the larger question, whether it would not be for the benefit of the Naval Service—

1. To change the present system of training our seamen, substituting for it another which would make our men-of-war's-men more fit and competent to serve in modern mastless ships of war; and,
2. To train our men of all classes, both seamen and stokers, to perform *all-round* duties.

(These duties will be defined by-and-bye.)

This question of the training of our seamen has been under discussion for the past two or three years, and many able men have presented it from several points of view. This will be fully dealt with in the next chapter, but it will be well for the present purpose to notice one of the contributors to the discussion. In the April (1891) number of the *United Service Magazine* an interesting article on the subject was contributed by Captain C. C. P. FitzGerald, R.N. In the exposition of his views he shows a singular absence of prejudice, and, fully accepting the altered conditions of the present Navy as compared with that of the past, he advocates a change in the training and

education of officers and men that will make them "fit in" with these altered conditions. He says:

"This education must be conducted with a view to the particular weapons with which they will be expected to fight," a proposition which surely no rational person will be inclined to contest, and which even prejudiced men will assent to, while it remains in the proposition stage. When, however, any attempt is made to carry it into effect, those who lag behind the times, and cannot divest their minds of old Navy ideas, will doubtless offer a most determined opposition to any change, except, perhaps, that of the very mildest character. It is probable that many, perhaps a majority of our senior naval officers, belong to this class, and of course they exercise an influence on those who administer the Navy corresponding to their rank. These are old Navy men, and hence in these days though our principal ships of war are wholly unlike those of only twenty years ago, being simply fighting and steaming machines, we see that the training of our sailor boys is exactly the same as in the old days, viz., "They are taught to reef topsails, to furl topgallant sails, and work a brig under sail," and "then sent to sea in a mastless battle-ship or cruiser," knowing absolutely nothing "about the ships in which they will have to fight," that being "quite outside the range of their education." These are Captain FitzGerald's weighty words, which deserve the most serious attention, when considering this important subject; for on the action taken in this matter of education depends the efficiency of the Navy of the future.

In connection with this subject, it may be said that there is nothing so unreasonable as prejudice, and few things more insurmountable; it often, nay, nearly always, prevents change when change would bring improvement: it is the greatest drag on rational progress. Therefore Captain FitzGerald deserves the thanks of all well-wishers to the Navy, for the vigorous onslaught he has made on the "desperately hard stone wall of prejudice which surrounds this question."

The tenour of Captain FitzGerald's article shows that he evidently had in view the training of all the lower ratings in general service as all-round men, for he asks the very important question, "Why should not . . . . the training of the so-called seamen and stokers be amalgamated?" This question has an important bearing on the subject of the war training of the Navy, and will, no doubt, be answered according to the peculiar views of the answerers; but it may be hoped that there are many officers of great experience and clear judgment, who, looking at the matter in a logical spirit, and desirous of training our men so as to make them thoroughly efficient in our modern Navy, will agree with Captain FitzGerald that there can be no reason why the suggested fusion should not be made, and all men entered for general service, and trained in all-round duties.

But, supposing this answer to be made, we have not made much progress, for we are at once met with the more important question, much more difficult to answer, viz., "How can this be done?" This question

can be best answered by obtaining the opinions of some of our most experienced officers, abstracting the most valuable and practical of these opinions, and founding a plan on them. I offer my suggestions on this subject with considerable diffidence, for I am conscious that there are many of our distinguished naval officers who are much more competent than myself to give an opinion on this matter of educating the seamen class to be all-round men.

As has been remarked, each of our modern warships may be regarded as divided into two grand divisions or departments, viz., gunnery and steam; and, for the purpose of our argument, gunnery might be held to include all general deck duties; and steam to include not only actual engine-room work, but also that in connection with auxiliary machinery—water-tight compartments, cocks and valves of all kinds, &c. And the question, therefore, might be put this way, "How can our future men be best trained into all-round men, able to work in both departments into which modern ships are divided?" I answer, "By instructing them *from the first* in those general duties which they will have to perform during their future career in the Navy, so that when drafted into sea-going ships they may be fairly competent in all-round duties, and become more useful as general service men by continued service and increased experience."

I suggest, then, that the present system of entering and training stokers be abolished, and that our future stokers shall be entered as boys, at the same age as boys of the seamen class. At present stokers are

entered between the ages of eighteen and twenty-eight, are very often imperfectly educated, and probably, for some time before entry, have been badly fed and clothed; they have no idea of discipline, and are quite ignorant of Naval Service routine when they join the guardship of Steam Reserve; they are kept in the Steam Reserves from six to twelve months, and employed as working parties, coaling ship, and doing other rough work, which does little to advance them in a knowledge of their special duties as stokers. They are drafted at the age, say, of nineteen into sea-going ships, while comparatively raw and inexperienced, and form a part of ships' complements, which are frequently small, even if every man were a well-trained and useful man. As one of the results of the summer manœuvres, several admirals and captains have made complaints as to the large proportion of second-class stokers sent to the ship as part of the complement, and commented on the inefficiency of these young stokers, as regards both ignorance of their duties and their want of stamina.

This, therefore, cannot be a good system, and should be abolished. As has been said, all the stoker class should be entered as boys at the same age as the seamen class. Perhaps a better way of saying this would be that there should be entered annually a number of boys sufficient to furnish the Navy with both seamen and stokers. All these boys should have one year, or one year-and-a-half, in stationary training-ships, in which they would be subject to discipline, well-fed and clothed; and receive, to fit them for their future career, all such instruction as can be given in these

ships. In each port there should be appointed a modern war-ship, of which there are many in every Reserve, for the purpose of instructing the boys in those appliances which are not fitted in the wooden training-ships. When they have completed their time in the harbour training-ships, they should be sent to sea on board a training squadron of steamships of modern type, in which, *from the first day on board*, they would be instructed in general duties, deck work, gunnery, stoking; everything necessary to make of these boys all-round men. Some will show an aptitude for gunnery, others for engine-room work and stoking. Those who take to gunnery might be considered gunners first and stokers afterwards, and be called gunner-stokers; and those who take to stoking, stokers first and gunners afterwards, and be called stoker-gunners. This is suggested, because it is considered probable that the boys and men, while in the lower ratings, would naturally form themselves into two divisions, each of which would be specially good in one thing, while fairly competent in the other. Of course every means must be used to make the all-round training of the boys as complete as possible, so that at the end of their course of instruction in the sea-going training squadron the boys at the age of eighteen or nineteen might be fit to draft into any of our modern ships of war.

Supposing this plan could be carried out, our young men-of-war's-men would, when drafted into sea-going war-ships, have passed through three or four years' instruction in the very duties they would have to perform as all-round men, and, therefore, would be, *from*

the first day they were drafted, competent to perform these duties fairly well; would go on from that point to acquire, by service and experience, superior skill, and so become with every year's service increasingly useful. It may be remarked here, that, after being drafted, the ability to perform all-round duties should be maintained and improved by the continual changing of the men from one service to another, as already proposed, all the time they are serving in the lower ratings.

Perhaps it would be well to endeavour to show how the proposed plan of training our future men, if it could be successfully carried out, would compare with the present system. This might be stated as follows:—

	Class.	By Present System.	By Proposed Plan.
When drafted to first sea-going ship as part complement.—Age 18 to 20.	Seamen.	Have passed through a course of instruction in stationary training-ships, sailing-brigs, and sea-going rigged steam-ships. Have no knowledge of stoking or engine-room duties.	Would have passed through a course of instruction in stationary training-ships, including a modern war-ship; in a sea-going ship of the same kind; and in all-round duties; including deck-work and gunnery, engine-room duties and stoking.
	Stoker.	Have been instructed in rifle and cutlass drill; have had very little training in engine-room duties; and have little or no experience or skill in stoking. Have no knowledge of deck duties, including gunnery.	Same as above, viz., would have been trained in engine-room duties, including stoking; and in general deck duties, including gunnery.

With regard to the advancement of these general

service men to the rating of petty officer, it would be well, as suggested by Captain FitzGerald and Mr. Edwards, to rate those who had shown special aptitude in gunnery as petty officers gunners, and those who excelled in engine-room work and stoking as petty officers stokers. After being rated petty officers, they should be kept serving in their own departments, as being more valuable and useful there than elsewhere.

By the foregoing statement it will be seen that the men trained under the proposed plan would, on being drafted into their first sea-going ship, be much more useful from the first day than those trained under the present system, which might be described as a system for training men into specialists, with the result that they are by no means skilful in the performance of their special duties, and know little or nothing of any others. It should be stated here that as regards the present training of the stoker class, a few of the newly-entered second-class stokers are sent from the Steam Reserves to the Channel Squadron and some of the troopships to be trained in stoking, but these are but a small fraction of the whole number, therefore the large majority of these young stokers are drafted straight from the Reserves into commissioned ships with little or no previous training in actual stoking. These young men are entered at the age of eighteen, and sent to ships, while still untrained, at about the age of nineteen, as already stated. It is considered that it would be advantageous to the Service if, in future, they were to be entered as boys of fifteen or sixteen, and, with the boys of the seamen class, had three or four years'

training in similar ships to those they would have to serve in, and in the actual duties they would hereafter have to perform.

I have now endeavoured to answer the question, "How can our future men-of-war's-men be trained into all-round men—our seamen class in stoking and engine-room duties, the stoker class in gunnery and deck duties—and all to have some knowledge of the several parts of the ships in which they will have to serve?" I am aware that several objections might be made to this plan; or, indeed, any other having the same end in view. Of these objections two might be mentioned as likely to prove the strongest. The first comes from the prejudiced men, "Let us," say they, "remain as we are." "Why make so great a change in our training system, which in the past has answered so well?" It is to be feared that it will be useless to address any argument to people who talk in this way, "because of the desperately hard stone wall of prejudice"; otherwise it might be said that it surely seems more reasonable to instruct our sailor boys, from the age of fifteen to eighteen or nineteen, in the very duties they will have to perform when drafted into modern war-ships than to spend time and money, and misuse energy and intelligence, in causing them to learn how to "reef topsails, furl topgallant-sails, and to work a brig under sail." These are the words of one of our distinguished and experienced captains, and nothing more need be said after the trenchant way in which he has dealt with the matter.

The other objection will be the expense incurred by

the change in the training system. The training of boys of the seamen class would probably not cost more than heretofore, for they must be trained in some way, and their instruction in all-round duties in a suitable squadron of sea-going steamships would not be more costly than in the present training squadron ; but undoubtedly there would be some additional expense caused by the entry of the stoker class in future as boys of fifteen or sixteen, and trained with the boys of the seamen class, as proposed by the plan. If, however, we wish to have a thoroughly efficient Navy, we must have regard to MEN as well as SHIPS. It is good in every way that the Navy should be strengthened and improved by the addition of seventy new ships, and the millions of pounds this will cost will be money well spent. But it is neither logical nor reasonable that, while we add these seventy new ships to the Navy, we should neglect, on the ground of its causing some additional expense, the education of the men who will have to take them to sea, to manage, and to fight them. If we spend millions every year in building and equipping costly ships of war, it is not reasonable to object to spending a few additional thousands to perfect the training of the men, so as to make them competent in every way to serve in those ships.

Is it necessary to say anything more in support of the assertion that our future men-of-war's-men require a different training to that of the seamen of the past? If so, we need do no more than say that our modern war-ships are dissimilar in almost every respect to those of the past. For instance, compare the three-

decked wooden line-of-battle ship of between 3,000 and 4,000 tons, carrying 130 guns (32 and 24-pounders), with the present first-class mastless battle-ship of 14,150 tons and 13,000 horse-power,* built of steel, with its enormous guns, its numerous compartments, its divisions and sub-divisions of hull, with their pipe connections, its auxiliary steam machinery (some of a very delicate and complicated character) in almost every part of the ship, and its massive propelling engines. Can anyone doubt that the men who will have to control and work these huge floating batteries, full of machinery, should receive a proper training to fit them to do so? The duties of the seamen of the past were performed on deck and *aloft.* Those of the seamen of the future will be performed on deck and *below.* It is obvious, therefore, that all men of the present and future Navy should be trained to perform with intelligence and skill, what we may call, "on deck and *below*" duties, in place of those "on deck and *aloft,*" and it is considered that this could be done by the proposed plan, or some modification of it. In any case it is hoped that the foregoing remarks and suggestions will be considered without prejudice, and that the outcome of any discussion of this important subject will be the adoption of a training system that will cause a great increase in the efficiency of the Navy.

* The *Royal Sovereign* at Portsmouth.

CHAPTER III.

THE TRAINING OF OUR SEAMEN.

Reference to the discussion of this subject from its commencement to the present time—Expression of opinions of many able officers—Brief review of the progress made in this discussion—Two questions submitted for consideration—Is the subject being seriously discussed in the Navy?—What is the general drift of the discussion, as shown by the opinions of our most able naval men?—Quotations from Admiral Fremantle's lecture on this subject before the Royal United Service Institution—His prevision of the wants of our future Navy—His evident wish for a considerable modification of the present training system—Subsequent discussion of the lecture—Weighty opinions of the Chairman, Admiral of the Fleet Sir John E. Commerell, V.C., in favour of the adoption of a new training system—If a change be necessary, should it be made at once or gradually?—This question fully considered—Difficulties experienced by naval reformers in dissipating prejudice in favour of obsolete systems, and in obtaining the adoption of those salutary changes necessary to make our seamen fully meet the requirements of modern seamanship—Remarks on the education of naval officers—Should it not include a general knowledge of ship construction, so that the effect of damage in action or otherwise as to trim, immersion, stability, and safety of ships might be understood, and remedies promptly applied?—Illustration of this by a reference to the loss of a war-ship, caused presumably, in some degree, by a want of this scientific knowledge of the principles of ship construction—Reasons given why the present circumstances call for such a revision of the training system as to make it comply with modern requirements.

THE discussion of this important subject, viz., the training of our seamen, has been carried on for some years past by many able officers, who, though perhaps persuaded that their views are

right, would doubtless admit that there is much to be said on both sides of the question, which is, whether the old system of training our seamen in the days of masts and sails should be retained, or a new one adopted, that would more fully meet the requirements of the present day, when the Navy is chiefly composed of mastless war-ships. Allowing for a little natural personal bias in favour of opinions once taken up, and which cannot be relinquished without a struggle, all will agree that the contributors to this discussion are actuated by a sincere desire to benefit the service to which they belong. We must not be too thin-skinned, if our views meet with severe criticism, and even condemnation. We may be sincere, and therefore give earnest and warm expression to our opinions; but their acceptance will depend on their soundness. If our views are not sound they will fail to convince, and will deserve to be abandoned.

There are two parties to this discussion who appear to hold diametrically opposite opinions, one advocating the retention of the present system, the other urging its abandonment in favour of another which will better meet the wants of our present and future Navy.

Many distinguished officers of rank, service, and experience have, from time to time, given expression to their views with much vigour and emphasis, and it may be useful to briefly review the discussion so far as it has gone up to the present time.

In April, 1891, Captain C. C. P. FitzGerald, R.N., published an article on this subject, advocating a change of the training system; and in July, 1891,

Captain G. Noel, R.N., published a reply to Captain FitzGerald, in favour of retaining our present system.*

Captain Noel refers to Captain FitzGerald's article as follows :—

"If it is possible that the gallant author is in earnest in what he writes, can any practical naval officer of standing agree with him ? Still, whether in earnest or not, such writings do *harm*, as shown by the article written by an engineer officer of high standing for the June number of the Magazine.† This officer innocently considers that he is supporting a sound proposition which is being seriously discussed in the Navy."

And from this point Captain Noel proceeds to write a pithy article, in which his views are propounded with the ability for which he is noted ; and so adds an instalment to the discussion of the general subject.

I will venture to remark here in reference to the foregoing quotation, that it is difficult to see in what way *harm* can be done by the discussion in any way, by any one, of a question of great public interest. It must be remembered that the views of the various writers are submitted to the fierce light of criticism, the criticism of a host of able men interested in the subject, and in the efficiency of the naval service ; and competent in every way to judge of the point, force, and soundness of the arguments advanced. Not only so, but it is certain that if any opinions are palpably

* April, 1891, and July, 1891, *United Service Magazine*, "War Training of the Navy."

† "Some Remarks on the War Training of the Navy," *United Service Magazine*, June, 1891.

unsound, not to say absurd, they will infallibly meet with prompt condemnation at the hands of the professional public, by whom they will be ignored, or their absurdity shown up in such a way as to kill the argument.

I propose in this chapter to ask two questions, the answers to which will bring before us the progress made, and the stage reached in the discussion of the subject of the training of the seamen of the Navy.

1. Is the subject—not only the general subject, but the particular views of all who join in the discussion of it—being seriously discussed in the Navy?
2. What is the general tendency and drift of the discussion up to the present time, as shown by the expressed opinions of our ablest professional men?

I answer the first question by referring to facts; and first, as to the discussion of the general subject. Captain Charles Johnstone, R.N., delivered an able lecture on the subject at the Royal United Service Institution, which elicited in subsequent discussion the opinions of some of the foremost naval men of the day. Captain Orford Churchill, R.N., refers to the subject in his paper * on "Manning the Navy." Vice-Admiral Sir Edmund Robert Fremantle lectured very recently on the "Training of our Seamen," at the Royal United Service Institution. Other officers of distinction who have taken part in the discussion of this subject are

* "Manning the Navy," by Captain O. Churchill, R.N., *United Service Magazine*, November, 1891.

Admirals of the Fleet Sir G. Hornby, Sir J. E. Commerell; Admirals Willes, Long, Colomb, Tracey, Bowden-Smith, Lindesay Brine, Field; Captains Fitz-Gerald, Noel, Johnstone, May, and many others.

Secondly, as to the discussion of particular views held by some: Admiral Fremantle said in the course of his lecture with reference to the propositions that the early education of seamen and stokers should be precisely the same.

"It may be that in time this might be advisable, and we might begin by training boys to be all-round men." It is only fair to say that the Admiral does not appear to be in favour of the proposition, at present at any rate; but the point is, that this very proposition, the soundness of which is challenged by Captain Noel, is in men's minds and thoughts, and they speak of it. Admiral Fremantle speaks of the possibility of its adoption at some future time; therefore it is to some extent being discussed; as to its soundness, the future will decide.

On the whole, it is certain that the subject of the training of our seamen is being seriously discussed in the Navy.

2. What is the general tendency and drift of the discussion up to the present time, as shown by the expressed opinions of our ablest men?

The general tendency of the discussion is distinctly in favour of a change in our training system—a change that will meet the requirements of our present and future Navy. It is interesting in this connection to note that Admiral Fremantle in his lecture, and Admiral

Long in his remarks, during the subsequent discussion, were the only officers who advocated the training of our seamen in the use of masts and sails; but both were of opinion that considerable modifications should be made in the present system, and both condemned the use of sailing-brigs as schools of instruction. Except in the case of these two officers, not a voice appears to have been raised in favour of retaining the present system, but there was emphatic expression of opinion in favour of its abandonment, and the substitution of another which would supply the wants of the present day. Thus, in the course of the discussion, after Admiral Fremantle's lecture, Admiral of the Fleet Sir John E. Commerell, V.C., Chairman of the meeting, said:

"Admiral Fremantle is pleased with the education of the boys in the training-ships . . . Is not this a little inconsistent? . . . He tells us you must do away with masts and yards and topsails, and yet he approves of training a boy upon a monkey-topsail. People complain that the time given to the education of our boys is not sufficient, and yet they are teaching them all these obsolete things. I do not think this education is satisfactory; and though it was revised only two years ago, I say, 'Tear it up, and start a new one.' . . We have to face a fact—it may be an unpalatable one to a great many of us; it is a very unpalatable one to me—and that fact is, that as *masts and sails have passed away*, the *training* of the men, in that line, who worked them, *will have to pass away too*."*

* *Vide* speech of Admiral of the Fleet Sir J. E. Commerell, in *Journal of the Royal United Service Institution*, for March, 1892, on "The Training of our Seamen." [The italics throughout this chapter are mine.—H.W.]

Thus spoke an Admiral of the Fleet, an officer of the highest distinction, in respect of rank, experience, service, and ability, whose opinions should surely have a weight, and an influence commensurate with his high position.

It is also worthy of note that Admiral Fremantle in his lecture, though advocating the retention of sail-drill in the training of our seamen, yet was distinctly in favour of some change in the present system, as *e.g.* he disapproved of the use of sailing-brigs; and he evidently looked forward to a time when it would be desirable to put sail-drill in the background, if not on one side altogether. In short, the whole drift of his lecture was in favour of change. He said in the course of his lecture:

"The path of wisdom is rather to look forward than backward," for as "the old order changeth . . . . it is our duty to endeavour, in the training of our seamen, to adapt them to their environment. . . . . The modern man-of-war is a complicated machine, and highly-trained officers and men are absolutely necessary. . . . . Stokers should be *entered as boys* . . . . *trained in gunnery* . . . all first-class ratings should be T.M." He approved of additional stokers being drafted to sea-going ships, so that a fourth watch might be formed, as suggested by Mr. Williams, with a view to all stokers working on deck—to learn deck duties—in turn. He disagreed with the opinion of a distinguished naval officer, quoted by Captain Noel, that the seamanship required was that learned "only with the help of the teaching power of

sails." The lecturer defines modern seamanship, showing that it is a different thing to the seamanship of the past, and gives some examples of the exhibition of good modern seamanship. "We must resign ourselves to gradually giving up the old seamanship, as it has in fact given us up."

But he made a still more remarkable expression of opinion, which has already been quoted, but it has such pertinence to the present argument that it will bear repetition. He refers to the proposals of Captain Fitz-Gerald and Mr. Williams that the early education of both seamen and stokers should be precisely the same. He can scarcely take these proposals seriously, but, with a prevision of the requirements of our future Navy, he says:

"It may be that, in time, this might be advisable, and we might begin by training boys to be 'all-round' men, as they propose."

Such were the gallant Admiral's principal opinions on the training of our seaman, and surely we may claim him as a very prominent member of the party of progress, his position in which is admirably expressed in his own words:

"I deprecate any attempt to put back the hands of the clock, and I would rather step forward to meet the change, which, however unpalatable, is *inevitable*."

The discussion that followed the delivery of the lecture was interesting as showing the balance of opinion in favour of changing the system of training our seamen. Admiral Bowden-Smith remarked that when the question was, on a former occasion, brought before the

Institution, the majority of opinions was decidedly against masts and sails.

Taking the foregoing into consideration and remembering the weighty words of Admiral of the Fleet Sir J. E. Commerell, have we not a right to say that the answer to the second question is that the general drift of the discussion up to the present time proves that many of our most able professional men are in favour of an abandonment—gradual or otherwise—of the present system of training our seamen, and the substitution of another that will more fully meet the requirements of the present Navy?

Thus the two questions arising from Captain Noel's remarks quoted at the commencement of this chapter have been answered by a reference to facts, and these answers show us the progress made in the discussion of this important subject.

It may be remarked here that Captains Noel and C. Johnstone, and some other officers of rank and distinction are in favour of the present system of training our men in the use of masts and sails.

There is one point in Admiral Fremantle's lecture that calls for some comment, viz., that while he appears to consider some change necessary, he would make it a gradual one.

To this it may be answered, that the change in our war-ships, from the old types to the new, appears to be nearly complete: that competent men to serve in the new types of ships are *now* wanted, and will be indispensable in the near future; and that the best way of obtaining these men is to at once commence to train

them for service in these modern war-ships. Does it not seem to be illogical to devote the best years of a boy's student life to carefully shaping him into a *round* man, with a view to making him fit a *square* hole? We have at present the square holes, and would it not be well to begin at once the training of our boys into the square shape? It would seem that the well-known aphorism about war should in this case be reversed. If a change in our training system must come sooner or later, let it be sooner rather than later.

There can be no doubt that reformers are often considered nuisances by many worthy people, who frequently are very irate at the advancement of novel opinions tending to upset old-fashioned but dearly-cherished ideas. For more than three hundred years, over nearly the whole of Europe, it was considered necessary in the general public interest, to burn and otherwise destroy witches; and the victims numbered millions! But some reformers succeeded at last in effecting the discontinuance of the practice. There is little doubt, however, that this was disapproved of by many of the old-fashioned people of that day, who naturally regarded any ceremony tending to the extirpation of evil as a distinctly religious ceremony, furnishing a considerable amount of pious enjoyment to all but the victims. So some of the opinions of reformers in these days are at first received with horror, afterwards regarded with complacency, and, by-and-bye, adopted with pleasure, and almost with enthusiasm. As to this question of the future training of our seamen, and the opinions of some that it is advis-

able to retain the old system, may we not ask whether some of these able men have not at times searchings of heart as to the soundness of their views? Surely it must be so, when so many naval officers of the highest rank and distinction are giving such emphatic expression to opinions favourable to the establishment of a *new* system, that will produce seamen competent in all respects to serve in modern mastless ships of war.

There is another matter which should not be omitted in the consideration of this subject, viz., the education of the officers who will serve in, and some of whom will command, our modern war-ships. This cannot be fully dealt with here, but a few remarks on the subject will be useful. Two questions may be asked:

1. How many of the executive officers serving in modern war-ships have an accurate knowledge of the names, positions, and uses of the numerous parts, divisions, and fittings, which, together, make up a ship of war?

Assuming that there are some few officers who have this knowledge, a still more important question must be asked:

2. Of these few officers who have an accurate know- of the names, positions, and uses of the numerous parts, divisions, and fittings, which make up a modern ship of war, how many have a scientific knowledge of the effect which would be caused by damage to hull, as regards immersion, trim, and even the safety of a ship?

It may be said, in answer, that there are always

highly-trained and competent engineer officers, who should possess this knowledge, and that is so; but is this enough? It is certain that the best of the executive officers would say that this was not enough. Also it seems to be possible that we may not always have a sufficient number of *highly-trained* engineer officers in the complements of our ships.*

In the old days of wooden war-ships, damage to hull, causing a great inflow of water, simply increased the immersion, but, there being no compartments, did not materially affect the *trim*.† The same damage to a modern war-ship would affect both *immersion* and *trim*, especially the latter. Suppose a ship received serious damage on one side, causing a very great and rapid inflow of water into the wing compartments, and others in connection with them, *on that side of the ship*, it is conceivable that the "trim" might be altered seriously, and, under unfavourable circumstances, dangerously, by giving an enormous "list" to the side that had been damaged. It is evident that there should be some on board who would know how such damage would affect tho stability, and therefore the safety, of the ship, and who would promptly take the surest means to ensure safety and restore efficiency. The ability to do this depends on a general knowledge of the construction of

* During the discussion of the Navy Estimates in the House of Commons, on the 14th March last, Captain Price, Conservative M.P. for Devonport, is reported to have said, "He rather doubted the First Lord's assurance that no difficulty was experienced in getting engineer officers. *The qualifications had been reduced*, simply because they could not get the class of men entered before." [Should our ships of war ever be engineered by a lower class of men than the present highly-trained officers, naval efficiency will be most seriously impaired.—H.W.]

† "Trim" athwartships.

the ship, and a scientific insight into the effect on stability of flooding by damage or otherwise of one or more of the compartments into which modern ships are divided.

Again, take the case of a battle-ship with a central protected battery and unarmoured ends, and suppose either or both of these unarmoured ends to be so damaged by ramming or perforation as to be flooded. What effect would this flooding have on

(*a*) Flotation ?
(*b*) Trim ?
(*c*) Stability ?
(*d*) Efficiency of fighting platform ?
(*e*) Safety of the ship ?

Besides the two supposed cases, others might be taken, but these will suffice for the present purpose. Meanwhile we may ask : Would not officers who had some scientific knowledge of the conditions under which their ships would be fought in future naval actions, have a great advantage over those who had no such knowledge ? These are points worthy of serious consideration when dealing with the subject of the education of naval officers.

As has been remarked, the whole subject cannot, and need not, be fully dealt with here; but enough has been written to show that it would be well if our young executive officers would devote some of their time and thought to the acquisition of this knowledge, which would be of great value to them, if they ever have to command a modern man-of-war.

An illustration of this part of my argument can be made by a reference to one of the most tragic events ever recorded in the naval history of this country —the loss of the *Captain*. As is well known, that ship had a fair amount of initial stability, but she also had a very low freeboard, and because of this, when, by the combined action of the wind and sea, she heeled over beyond a certain angle, she reached the point of vanishing stability with a dangerous, and, as it proved, a fatal rapidity. No reflection can be made on the Captain of that ill-fated ship, for he was a most gallant officer, of proved courage and capacity, and, moreover, the ship was one of the first of our modern war-ships, and the officers of that time—more than twenty years ago—had not the facilities for acquiring a knowledge of scientific detail as our present officers have; but in illustration of this point, may we not ask whether, if the principal officers on board the *Captain* had had a scientific knowledge of the *exact conditions* under which the ship was being sailed the night she foundered, she might not possibly be afloat now?

To conclude: The expressed opinions of many distinguished men show that, in their belief, the fact of our present Navy being in almost every respect dissimilar to that of the past, seems to call for such a revision of the training system as will make the *personnel* of the fleet fit in with the altered conditions.

CHAPTER IV.

THE TRAINING OF OUR SEAMEN—CONTINUED.

Reference to the three preceding chapters—Will the suggested changes, if adopted, benefit the naval service, and especially the Navy of the future?—Definite plans in detail submitted for the carrying out of proposed changes—Remarks on contents of first chapter – Our gunnery establishments—Expense incurred in training 12,000 non-combatants into skilled gunners—Remarks on contents of second chapter —Training men of all classes, from their entry as boys, into all-round men—Third chapter: Opinions of many able naval officers—Characteristics of men holding different views—The Navy, considered primarily as a war service—What training system is required to make such a service perfect?—What ships in future wars will be sent out to fight the country's battles?—Mastless ships—No rigged ships will be sent; therefore no seamen will be required to serve in such ships; and no training in such service is required—Should our sailor boys' student life be wasted by teaching them to do things they will never be required to do?—Definition of the duties of the seamen of the past, and the future—Means suggested whereby activity, strength, and capacity to do harassing work might be developed in our future seamen—Statement of what should be the chief aim of any training system—Conclusion.

IN the three preceding chapters some suggestions have been made, which, if carried out, will, it is considered, benefit the naval service, and especially the Navy of the future. When the adoption of any of these suggestions would involve any considerable change in present systems, a definite plan of the new system has been formulated in detail. Thus in the first chapter remarks are made on the large and increasing proportion of non-combatants, carried as part of the

crew of every sea-going ship of war. The total number of these non-combatants amount to many thousands; one class alone, the stoker class, numbering about 12,000 men. The statement was made that it was desirable to reduce the large proportion of non-combatants now carried as part of the crews of our war-ships. These men form from 27 to 40 per cent. of the ships' crews, and as the stoker class in the Navy amount to between 60 and 70 per cent. of the whole number of non-combatants, it was suggested that, if possible, the whole of this class should be trained in combatant duties, *i.e.*, be trained into skilled gunners. But this must be done in such a way as not to lessen their efficiency in the performance of their special duties as stokers. This would appear to be difficult, but, as already stated, a definite scheme has been formulated in the first chapter, in very considerable detail, whereby, it is contended, this great improvement can be carried out easily, inexpensively, and automatically, the only stipulation made being, that the scheme *must* be carried out *in its entirety*, and that especially, as the chief end aimed at is to make all the stoker class more or less skilled in gunnery, there should be no tinkering at the scheme, by adopting one part of it, and entirely omitting another; such, for instance, as training the men in general deck duties, but omitting instruction in gunnery. Also, in the course of the chapter, several possible objections to the scheme were considered, and answered. Thus the scheme was set forth in so plain a manner that there cannot possibly be any misunderstanding as to the exact means in every

detail, to be used in order to achieve the great end aimed at, viz., the conversion of 12,000 non-combatants now in the Navy into combatants, in the way, and under the conditions, set forth at the end of the first chapter.

It will be well here to notice, briefly, some opinions expressed on this subject by Captain G. Noel, R.N.* He says: "Nothing is more simple than the working of guns on board ship . . . . . . a hand from the plough with an eye for making a straight furrow, might, in a week, be taught to fight a quick-firing gun as perfectly as a first-class seaman-gunner." And again: "Any intelligent man, brought up as a man-of-war's man at sea, would master all the difficulties and complications—if they really exist (?)—of the newest invention in the way of a gun, and after a month's proper exercise on board his ship, would make as good use of it . . . . . . as he could after a three years' commission."

It is possible that these opinions will be demurred to by many able officers, who appear to hold very different views on this matter. In any case, if Captain Noel's opinions are sound, the operation of converting 12,000 non-combatants into skilled fighting-men, will be easier and more simple than was anticipated by the author of the scheme, and there seems to be no reason why it should not be done at once.

A few words as to the expense: An officer of high rank and distinction, with whose friendship I am privi-

* "War Training of the Navy," by Captain G. Noel, *United Service Magazine*, July, 1891.

leged, expressed the opinion that, under the operation of the scheme, the stoker-gunner would be a cheaper product than the seaman-gunner, because of *the expensive training of the seamen;* and notwithstanding that the stoker-gunner would be a slightly higher paid rating than the seaman-gunner.

It will be admitted that our gunnery establishments are costly institutions, and therefore that the training of the seamen in gunnery *is* expensive. But why should these costly establishments be maintained? Why should this expensive training be given if Captain Noel's quoted opinion be correct?

There can be no doubt that our gunnery establishments are most useful as schools of instruction, and, in fact, absolutely essential as contributing to the efficiency of the complements of our sea-going men-of-war, for of course gunnery is the chief element of fighting power in the Navy as a war service.

As in the first chapter, so also in the second, remarks are made on the general training of our seamen, and on the question whether a change of system is not required to meet the wants created by the very great changes which have been made in the Navy during the past forty years—changes in respect of material, armament, build, rig, tonnage, engine power, &c., &c., &c., of our war-ships? Modern war-ships are mastless, and in consequence the old seamanship seems to be obsolete, to be dead, and in place of it we have the modern seamanship, which has been so well defined by an English Admiral, and explained elsewhere. The question was asked: Should not a new system of training

our seamen be directed towards shaping them into all-round men, whose duties henceforth would be performed on *deck and below*, instead of on *deck and aloft*, as heretofore? Whether, in fact, men of all classes, seamen and stokers, should not be trained to be able to work on deck, between decks, below in the engine-rooms and stokeholds, and in boats? Assuming that this is desirable, a definite plan in detail is proposed for training all our men in these all-round duties, so as to make them competent to work in any part of the two great divisions into which modern war-ships are divided.

In the third chapter a summary of the opinions of many of the most experienced and able of our naval officers is given, and this will show in what direction, and how far in that direction, the opinions of those able men go, and that those opinions are distinctly in favour of a change in the system of training our future seamen. At the present time, now some years after the commencement of the discussion of this subject, it will be seen that it has been thoroughly threshed out, discussed, and argued from every possible point of view. It is now no longer considered heresy to advocate a change in our training system, and, in fact, many officers who were once opposed to any change, have altogether ceased to give the emphatic expression to their opinions they once did. Also, as has been seen, many officers of high rank and distinction have pronounced in favour of an entire change, the new training system to be based on the requirements of modern seamanship. It is interesting to note that the parties to this discussion vary in their opinions, and in the emphasis with which

they express them. First: There are those who advocate, without any modification, the retention of the present system of making instruction in the use of masts and sails, and all the fittings and operations connected therewith, the chief element in the training of our future seamen. Secondly: There are those who are in favour of compromise, *i.e.*, the retention of instruction in masted and rigged ships, but with such modifications as would put it more or less in the background. And, thirdly, there are not a few who are in favour of a radical change, that will make our seamen experts in modern seamanship. To these may be added those who silently wait for the course of events, and of them it may be said that they seldom influence, in any great degree, the issue of the discussion of a subject of great public interest.

Considering the Navy as primarily a war service, it will not be disputed that the chief aim of a training system should be to turn out men competent in every way to make that war service as perfect as possible, and it may be asked, What ships in case of war would be sent out to fight the country's battles? The answer must be: Modern mastless ships of war. It may further be asked: What ships will *not* be sent? And we answer: Masted and rigged ships of any kind will *not* be sent. But our seamen by the present system are taught to serve in masted and rigged ships, which will never more be wanted or used in future wars. Can this system which teaches our seamen to do, what, in actual war service, they will never be required to do, be good for the Navy and the country?

It was well said by Admiral of the Fleet Sir John Commerell, that our sailor boys' student time was too short to teach them all they were required to know, and that a great part of this valuable time was taken up in teaching them the old seamanship, which many think is quite obsolete. But if a boy's student time is too short to teach him all he is required to know to fit him for service in future war-ships, does it not seem to be unreasonable, and irrational in the highest degree, to take up a great part of that time in teaching him to do what he will never be required to do? Yet irrational as it may appear, it would seem to have been decided to continue the system, for it has only recently been announced in the press that another sea-going masted ship is to be fitted and appropriated as a school of instruction for our young seamen.

It is, however, not enough to say that the old system is antiquated, and fails to supply us with competent men to serve in modern war-ships. Another system is wanted that will do this. Such a system is proposed in chapter second, wherein I have endeavoured to prescribe a course of instruction for seamen of all classes —stokers as well as seamen—from the time they are entered as boys—as they all should be—to the age of nineteen, when they should be able to perform all-round duties, below as well as upon deck, gunnery, stoking, in boats, every kind of service required in a modern mastless ship of war, in which they will undoubtedly have to fight the naval battles of the future.

If the time now wasted—as some think—by our sailor boys, in the acquisition of expertness in working

masts and sails, were utilised by instructing them in the performance of such duties as would make them "all-round" men, it would produce men more fit to meet the demands of modern seamanship than by the present method. To quote a sentence in the second chapter:

"The duties of the seamen of the past were performed on deck and *aloft*. Those of the seamen of the future will be performed on deck and *below*. Therefore all men of the present and future Navy should be trained to perform with intelligence and skill what we may call on 'deck and *below*' duties, in place of those on 'deck and *aloft*.'"

Two able men in our Navy, Captains G. Noel and C. Johnstone, have expressed very decided opinions in favour of the continuance of the present system of training our seamen. Their views are entitled to attention and respect, as those of officers holding a deservedly high position in the Navy. But they have both been in command of sea-going rigged training ships, and have taken a considerable part in the training of many of our seamen. Now may not their opinions, because of this service, be biassed—unconsciously biassed? When, in the fable, the shoemaker was asked his opinion as to the best material to make a fortress, he answered, "Nothing like leather," an answer that showed bias. Similarly, had Captains Noel and Johnstone served all their time since they were lieutenants in mastless battle-ships and cruisers, might not their views on this subject have been different?

It is easy and natural to feel a great admiration for

the old seamanship, and the muscular, brawny, active seamen it produced. We must all feel this admiration, and regret the necessity for the discontinuance of such a system. It is—to use Admiral Commerell's words—"very unpalatable" to be obliged to come to the decision that "as masts and sails have passed away, the *training of the men*, in that line who worked them, will have to pass away too." The question here is, not whether the old training system produced splendid men equal to the wants of the old seamanship, but whether the requirements of modern seamanship do not call for such a new training system as will meet those requirements?

As the wants of the future as well as the present Navy are now being considered, it will be well to ask a few questions.

Of the seventy new ships of war that will be shortly added to the Navy, and will form a considerable fraction of the whole fleet, how many will be masted ships, built to make passages under sail? *Not one.* Do the authorities contemplate building, in the future, any masted ships? Apparently not. Then ten years hence it is possible, nay probable, that there will not be a single masted and rigged ship of war in commission, except, strangely enough—should the present system be continued—the *masted* ships, in which our seamen will be trained for service in *mastless* ships!

There is no doubt that activity, strength, and capacity to do harassing work will still be required in our seamen, and one of the details in our future training system would have to be a means of developing mus-

cular strength by exercises in athleticism. Probably much of this would be done by the ordinary work in the ships and boats, but if anything in addition be wanted, a gymnasium, temporary or otherwise, might be arranged somewhere between decks, where the boys should be required to take exercise, and prizes might with advantage be awarded to those who excelled in these gymnastic exercises. Indeed it would be very beneficial if this were continued after the boys became men, and they were encouraged by the officers, both by precept and example, to consider these exercises as the principal means of recreation after the work of the day was done.

This subject has now been presented in some detail, and the opinions of many of our most able public men quoted. When we note the experience, distinction, and rank of those in favour of some change in the system of training our seamen, it would seem that there must, at some future time, probably in the near future, be a serious consideration of the whole subject. This could be best done by the assembling of a number of experienced men, representing all shades of opinion, to discuss, in an impartial spirit, the several questions that would arise, and reporting the result to the authorities.

To conclude: The words of an Admiral of the Fleet* will bear repetition here. The *old seamanship* has "passed away," and in place of it we have the *modern*

* Sir John Commerell, V.C., G.C.B., R.N. "The Training of our Seamen." Speeches. *Vide Journal of the Royal United Service Institution* for March, 1892.

seamanship, well defined by another Admiral.* Therefore the chief aim of any training system should be the production of men thoroughly expert in the exercise of that modern seamanship, that will undoubtedly be the seamanship of the future.

* Sir E. R. Fremantle, K.C.B., C.M.G., R.N. "The Training of our Seamen." Speeches. *Vide Journal of the Royal United Service Institution* for March, 1892.

PART II.

SHIPS AND MACHINERY.

PART II.

CHAPTER I.

FORCED DRAUGHT IN BOILERS OF WAR-SHIPS.

Changes in the machinery of Her Majesty's ships gradually, but continuously, made for several years past—Engines from simple to compound, and from compound to triple expansion—Necessitating the use of very high-pressure steam, and the manufacture of boilers capable of bearing safely the greater strain due to the higher pressure—Abolition of sail-power in modern battle-ships and cruisers—Results: Lessening the weight carried, and giving increased flotation, but neutralised by increased weight of armament; heavy protective plating; more auxiliary steam machinery; duplication of propelling engines, and the necessity for great coal-carrying capacity—To meet this: Weight of engines and boilers reduced, the latter to too great an extent—Forced draught: Description—Definition of excessive forced draught and limited forced draught—Use of excessive forced draught unsafe, as proved by very numerous breakdowns of new boilers under the strain—A limited and safe forced draught suggested—Reasons for this limitation—Illustrations of the result as to speed of vessel, and development of engine power, of the use of the excessive and the limited forced draught—No instances on record of the failure of new boilers by the use of a purely natural draught—Nature of injury done to boilers by the use of an excessive forced draught—What causes this injury?—Full discussion and explanation in detail—Traced to imperfect contact between the water and the heating surface of plates and tubes—What should be done with the large number of ships in which the excessive forced draught must be used to get the maximum contract engine power—What measures to adopt in future ships to ensure that the maximum contract power and speed should be obtained as regards the boilers under safe conditions—What constitutes an ideally perfect ship of war?—That the four grand dimensions in which every ship can be divided are each up to an equally high point of efficiency—Divisions—Hull—Armament—Engines—Boilers—

The weak link in this chain—Boilers—Should we not endeavour to lead, and not be content to follow, other nations in producing as close an approximation as possible to the ideally perfect ship of war?—Conclusion.

FOR several years past the steam machinery of Her Majesty's ships has been going through a process of change, both as regards design and the material of which it is made. First the change was from simple to compound engines, and in modern ships we have now the three-cylinder triple-expansion type. Also in our battle-ships and cruisers the twin-screw principle has been adopted, involving the fitting in each ship of two complete sets of engines, each made to work independently of the other.

The adoption of the triple-expansion type of engines necessitated the use of steam of much higher pressure than formerly, and at present the boiler steam pressure ranges from 100 lbs. to 150 lbs. on the square inch. The boilers therefore have to be made of sufficient strength to withstand this pressure safely, and there has been found no difficulty in this, because they are made for the most part of mild steel of great tenacity. But as regards the heating surfaces, viz., the furnaces, combustion chambers, tubes and tube-plates, there is obviously a limit to the thickness, and therefore the strength of the material of which they are made, because of the necessity for having perfect conduction of heat through them to the water in the boilers, so as to ensure that the temperature of the plates shall be kept down to a safe point, and so prevent injury by overheating, softening, and burning.

But other changes in addition to those in the machin-

ery have been, and are being made. In our battleships and cruisers sail power has been abandoned, resulting in the lessening of the weight carried and giving increased flotation. This, however, has been neutralised by the increased weight of armament; the heavy plating of vital parts of the ships; the great amount of auxiliary steam machinery now fitted; the duplication of the propelling engines; and, lastly, the necessity for a great coal-carrying capacity. On the whole, it has been deemed necessary, in order to meet the requirements, to reduce the weight of the machinery and boilers as low as possible; and it is contended that as regards the boilers this has been done to an injurious extent, it being found impossible, in many of our modern ships, for the boilers to supply, under safe conditions, the engines with sufficient steam for the development of the maximum indicated horse-power specified for on the contractors' full-power trial under forced draught.

On these trials the maximum air pressure allowed in the boiler-rooms is two inches; and when the term "forced draught" is used without qualification in this chapter, by it will be meant the forced draught which has an air pressure of about two inches. This remark is made here because it is considered that the use of a limited forced draught with an air pressure of about half-an-inch is quite safe, and beneficial in the development of power, as it ensures a very free supply of air to the furnaces for the purpose of quick and perfect combustion.

The contractors' full-power trials under forced draught

of new ships have, for some time past, in many cases been unsatisfactory, and this has been caused by the failure of the boilers to bear the strain imposed upon them while trying to get the highest contract full power out of them under forced draught, with the maximum air pressure allowed.

In order to show the enormous strain brought on the boilers by the use of forced draught with the higher air pressure, it will be well here to compare the actual work done under two sets of circumstances, viz. :—

1. A very forced strong natural draught.

2. Forced draught.

Taking the first-class belted cruiser *Aurora*, the particulars would be as follows :—

	Indicated Horse-Power.
1. Under a very strong natural draught, or its equivalent, a limited forced draught, with an air pressure not exceeding half-an-inch	5,500
2. Under forced draught, air pressure about two inches ...	8,500
Difference	3,000

Thus the additional strain brought on the boilers of the *Aurora* by the use of forced draught is represented by no less than 3,000 horse-power advance on the 5,500 horse-power; an advance of more than 50 per cent. on that developed under the safe conditions of the limited forced draught as described.

In former days, the only thing analogous to the forced draught of the present time was the induced draught caused by the steam blast in the funnels; and it is noticeable that the only breakdowns of new boilers in those days were caused in all cases by the excessive

use of this steam blast. Also, it may be remarked, that there is scarcely any, if there be any, instances on record of well-made new boilers ever giving way under the use of a purely natural draught, *i.e.*, without the passage of air through the fires being accelerated by artificial means.

Since that time great improvement has been made in the strength of material and excellence of workmanship. Also the officials who have the control and management of the machinery of the fleet are superior to those of former days, who had not as many calls upon their carefulness and skill; and yet the cases of failure of the boilers in those days were few, while in these they are many.

Why is this? There is but one answer. It is because of the use of forced draught. What is forced draught, and how is it obtained? It is driving air with more or less velocity through the fires in the furnaces, causing a kind of "blow-pipe" action to be set up, resulting in the generation of intense heat in furnaces, combustion chambers, and tubes. The evaporation of the water inside the boilers is more or less rapid in proportion to the temperature of the plates, &c., with which it is in contact; this temperature depends on the velocity of the air passing through the fires, and this velocity is determined by the air pressure in the stokeholds. As, therefore, the action of the forced draught is governed by this air pressure, it follows that the extent to which the forced draught is used may be accurately measured by stating the air pressure. For example, it is considered that a limited

forced draught represented by an air pressure of about half-an-inch is absolutely safe and very beneficial; while, on the contrary, the forced draught with two inches air pressure is unsafe, and likely to injure the boilers.

To get the air pressure the stokeholds are closed and made air-tight, the only vent being through the ash-pits, furnaces, combustion chambers, tubes, and out through the funnels. Air is pumped into the stokeholds by large fans until the required pressure is obtained, this pressure being measured by water-gauges, indexed by inches and parts of inches. When the boilers are put under forced draught, it is obvious that as the only vent for the compressed air is through the fires, the velocity of the air depends on the pressure in the stokehold. As this pressure increases, the velocity of the air currents through the fires increases; the heat generated in the furnaces is more intense, the evaporation of the water more rapid, and the generation of steam quicker. There is, in fact, no limit to this except—the ability of boilers to bear the strain. Unfortunately this limit exists, and the fixing of this is of primary importance; for, allowing for a safe margin under this limit, there is no reason why the boilers should suffer injury, but over it, there is great probability of their breaking down under the strain.

The injury done to the boilers generally shows itself in two respects, viz., by the stays and riveted seams becoming defective, and by excessive leakage of the tubes at the fire-box ends of the boilers, the latter always giving most trouble.

This being so, the question arises, Why should the use of forced draught cause these defects in the boilers? It is probable that nearly the whole of the damage done is due to the excessively high temperatures of the parts exposed to the action of the flame, viz., the combustion chambers, tube plates, and the fire-box ends of the tubes, this high temperature being caused by the imperfect conduction of the heat through the plates to the water, or it would be better to say that the *contact* of the water with the plates is not perfect enough to keep them at a safe temperature. This is probably caused as follows: The intense heat in the combustion chambers and tubes, generated by the "blow-pipe" action of the forced draught, quickly evaporates the water in contact with the plates, and great quantities of steam are given off from them. The steam, in passing through the water, lifts it, to some extent, away from the plates, so that what is in contact with them is not water, but a mixture of water and steam; and while this is sufficient to prevent serious softening and bulging of the plates, it does not prevent so much over-heating as to make the tubes and stays give way under the strain due to end-on expansion of the furnaces and tubes. These parts are stayed to the ends and outside shell of the boiler in the direction of its length, but the end-on expansion of the tubes and furnaces is much greater than that of the outside shell, because of the difference of temperature; and therefore the tubes are forced through the holes in the plates while in the over-heated condition, bringing on the excessive leakage which makes the boiler unserviceable.

In support of the theory that imperfect contact of the water and the plates causes leakage, it may be remarked that a scale of an eighth of an inch on the fire-box tube plates is quite enough to cause leakage of the tubes, even with only a strong natural draught. Under forced draught, boilers in this condition could not be steamed for an hour without breaking down. Now, in this case, the interposition of the non-conducting scale prevents contact of the water and the plates, and this causes the over-heating and softening of the tubes and the tube plates which bring on leakage.

As, therefore, the presence of scale on the fire-box tube plates causes leakage of the tubes, because of there not being perfect contact between the water and the plates, so it is considered probable that in the case of new clean boilers forced draught makes the tubes leak from the same cause, viz., imperfect contact of the water and plates by the giving off of large quantities of steam from the heating surfaces, and lifting the water away from them.

If this theory be true, it will account for the leakage brought on by the use of forced draught, even though the boilers have not been short of water at any time during the trial. Several instances of this kind have come under the writer's own personal notice.

Also, if this theory be true, it is probable that, with boilers designed as at present, the use of forced draught with high air pressures will always cause leakage. In the present boilers, the greater part of the heating surface is contained in nests of tubes, in a comparatively small space, and with very small water spaces between

the tubes. Thus, when steam is given off freely from the tubes, the circulation of the water round them is hindered, because of the smallness of the water spaces; the water is lifted away from the tubes as described, and prevents the contact which is necessary to keep them at a safe temperature.

In further proof of the truth of this theory, it may be remarked that in cases where, in a boilĕr, a scale has been deposited on the furnace crowns and tops of combustion chambers, it has been found that on the forced draught being used the plates have bulged between the stays, showing that the contact of the water with the plates has not been perfect; that they have been over-heated, and while in the softened condition bulged, as described, by internal pressure.

Having dealt with the matter technically, and described forced draught, stating why, and under what circumstances, its use is detrimental to the boilers, I will go on to touch on some of the general aspects of the matter, premising that it will be allowed that for some time past there have been many failures of boilers of new ships under the experimental test of the contractors' full-power trials, and that these failures have occurred when using forced draught with the maximum air pressure allowed, viz., two inches.

In view of the serious risk of injuring the boilers, it may be asked what is the advantage gained; and it will be found that the real practical gain is very small.

The results of contractors' full-power trials of several new ships have been taken in order to show the average gain in indicated horse-power and speed due to the use

of the forced draught with the higher air pressure. These ships were tried under two sets of circumstances, viz:—

1. Under a very strong natural draught, or its equivalent, a limited forced draught, with an air pressure of a quarter to half an inch. (This is called the natural-draught trial, but this small air pressure is allowed to be used.)
2. Under forced draught, with a maximum air pressure of two inches, the highest allowed.

The results of the trials show that by increasing the limited forced draught—air pressure, quarter to half inch—to the maximum—air pressure, two inches—the average gain is as follows:—

Indicated horse-power ...	about 54	per cent.
Speed in knots	„ 11	„

Take an instance: In the case of the first-class belted cruiser *Aurora*, on the actual trial under the two circumstances, the difference of the indicated horse-power developed was as 5,706 to 9,013, viz., 57 per cent., the difference of the speed of ship being as 17·15 knots to 18·53 knots, a little over 8 per cent. In other words, the strain on the boilers is increased 57 per cent. to gain an 8 per cent. advance in speed of ship. And the question must be asked: Is it rational to incur so great a risk for so small a gain?

It will be well to consider here that the breaking down of the boilers and mishaps to the propelling engines are different in kind and in their consequences. In nearly all cases the propelling engines in our battleships and cruisers are duplicated; each ship has twin

screws, with a complete set of engines to drive each propeller; each set made to work independently of the other in every respect. As the engines are made of sufficient strength to safely bear the strain due to the greatest horse-power obtained by the use of the maximum forced draught, it is very improbable that both of these sets of engines would break down at the same time. Now, as each set of engines, acting on its own propeller, is capable of driving the ship from 60 to 70 per cent. of the full speed obtainable from both sets and propellers, it follows that with one set quite broken down a ship is far from being disabled, but is quite capable of going into action, fighting a battle, and coming out of action safely. Not so with the boilers: their breakdown causes both sets of engines to be unserviceable, and renders the ship unmanageable. And when it is considered that our battle-ships and cruisers are wholly dependent on their steam propelling machinery for their efficient manœuvring power, it will be admitted that it is a matter of the most vital importance that our ships should be capable of being steamed under conditions absolutely certain to ensure the continuous soundness and efficiency of the boilers.

But some may say, there are always more than one boiler in every ship, and each can be worked independently of the others; therefore the same argument applies to them as to the engines, viz., that it is unlikely all would break down at the same time. Unfortunately, experience shows that this is not so; on the contrary, it is highly probable that the strain which would break one boiler down would have the same effect on the

others. When trials under forced draught have had to be abandoned because of the failure of, say two of four boilers, it has often been found on subsequent examination that leakage had commenced in the other two, the breakdown of which was but a question of time, and probably a very short time. Therefore the same argument cannot safely be applied to the boilers as to the engines.

But we will go on to consider further, whether there is so much practical gain in speed and manœuvring power as to justify incurring the serious risk of crippling the boilers by putting the enormous additional strain on them, due to the use of the forced draught with the maximum air pressure, viz., two inches. The advocates of this forced draught say that its use is of great value, because in time of emergency it enables us to increase the indicated horse-power and speed of ship respectively 50 and 10 per cent. Let us examine this: It is assumed that there are three cases in which it might be useful, if it could be safely done, to utilise this increase of power and speed in a time of war.

1. When desirable to proceed with the utmost despatch to engage the enemy from a home port to a place say 2,000 miles distant.
2. When manœuvring in action.
3. When coming out of action and running before a greatly superior force of the enemy.

We will take the first case, and suppose that there are three battle-ships and six belted cruisers in Plymouth Sound, all with a full speed of 18 knots with the higher forced draught power, and of 16½ knots

with the lower, the safe, forced draught power. In the light of the experience of the past ten years, would any Admiral order the ships to be steamed at full power under forced draught with the highest air pressure allowed on contractors' trials? If so, would not the engineer officers represent to their Captains and Admiral the probable, indeed certain, breakdown of the boilers before the arrival of the ships at their destination if this order were carried out? On the contrary, would not the direction be to proceed at the highest speed obtainable under conditions that would ensure the boilers remaining sound and efficient? And yet these are the circumstances under which the additional horse-power and speed obtained by the forced draught are most wanted. If this maximum forced draught cannot be safely used when urgently wanted, of what practical use can it be at any time? The same argument applies to the other two cases, viz., when manœuvring in and going out of action. Success would undoubtedly attend the evolution of those ships which were worked at the highest power and speed, obtained under absolutely safe conditions as regards the boilers.

It may be asked here: Might not the failure of the boilers on contractors' full-power trials be due to other causes than the use of the forced draught with the higher air pressure? The answer is found in the circumstances under which the trials are made, viz., the boilers are new, and therefore at their greatest strength; they are designed by experienced engineers, made of the best material by the best engine makers, and under the supervision of experienced Admiralty

officials. Moreover the trials are made under favourable circumstances as to weather, carried out by picked men, under the orders of skilled officers, and in the presence of representatives of the Admiralty, Dockyards, Steam Reserves, and Contractors, all more or less experienced in the management of forced-draught trials. These circumstances are favourable, and should ensure satisfactory results, yet the failures take place, and we are compelled to conclude that they are caused by the inability of the boilers to stand the strain due to the two-inch air pressure.

Of course this applies with greater force to all vessels in which it will be necessary to use a higher air pressure than even two inches before the contract full power can be obtained.*

In view of the foregoing, it may be asked, What should be done with new ships coming on for trial? It is answered that it would be well to dispense with the present contractors' full-power trial under forced draught with the high air pressure allowed; the only trial considered necessary being that under a limited forced draught with an air pressure of about half-an-inch.

If this be done all full-power trials will be made with a certainty that no injury, permanent or otherwise, will be done by excessive straining of the boilers; with a loss of only about 10 per cent. of the full speed obtained by the use of the higher air pressure; and resulting in a real horse-power and speed being obtained, available for making passages, and therefore useful in the highest degree, in place of the power and

* As, *e.g.*, in the "Sharpshooter" class.

speed got by the maximum forced draught, and only obtained at the serious risk of breaking the boilers down.

But some may say: Why fix the limit of air pressure at half-an-inch, and not at some point between half-an-inch and two inches? For we then should get the benefit of the higher air pressure. The answer is, that, judging from the results of trials, the half-inch limit is safe, for the trials with its use are invariably most satisfactory in every respect; while the two-inch limit is unsafe, because the trials with it result in many failures; any departure from the safe limit is therefore an approach to the unsafe. Now, there should be a considerable margin; a reserve of strength, in the boilers, sufficient to ensure that, under all circumstances, ships might be steamed with absolute safety. And this can be done by the adoption of the half-inch limit, which will give the necessary reserve of strength.

Let it be supposed that the air pressure, the maximum allowed, be reduced from two inches to $1\frac{1}{2}$ or $1\frac{1}{4}$, or even one inch; it is admitted that in consequence of this the *contractors' trials* might probably be satisfactory, because the boilers would be *new and clean;* but the question is, not whether the boilers in this condition, and with the reduced air pressure, would have a satisfactory full-power trial of *four hours' duration,* but whether the boilers would remain continuously efficient during the forthcoming *four years' commission.* It is part of the alphabet of engineering science that to ensure safety in any structure or piece of machinery there must be a very considerable difference between the

highest actual strain and the breaking strain. Hence the half-inch limit of air pressure is suggested as giving the difference that will ensure the safety.

Although in vessels already in the Service, or coming on for trial, the gain in speed of about 10 per cent. is so small as to make it not worth the risk of breaking the boilers down by the use of forced draught with the higher air pressure, yet it is admitted that the higher power and speed so obtained would be of great value if they could be obtained with safety.

This higher power and speed could be obtained with safety if, in all ships built in future, the boilers were made large enough to supply the engines with sufficient steam to develop the highest horse-power, with the use of the lower, *i.e.*, half-inch air pressure. Even if this should not be deemed necessary in the smaller ships, it should be done in the case of our battle-ships and large cruisers, which will doubtless have to bear the brunt of the big naval battles of the future.

It is true that fitting larger boilers in ships would cause some additional expense, and that the additional weight to be carried and the increased space required in the ships would have to be provided for. These are drawbacks; but the gain in efficiency far outweighs the drawbacks, as will be seen by-and-bye, and surely it is within the resources of naval architectural science to surmount these difficulties, and give us a more perfect ship of war than we possess at present.

It would be well to consider here what is understood by a perfect ship of war, or perhaps we should rather say the closest approximation to that ideal ship. It is

surely that ship in which the several parts are each up to an equally high point of efficiency, *i.e.*, that no part shall, in this respect, fall far below the others. A ship may be regarded as in four parts or divisions, viz.:—

1. Hull.
2. Armament.
3. Engines.
4. Boilers.

Taking these in order, we have—

1st. The hull, with all its details, including its many subdivisions; the protection of vital parts; its flotation to comply with weight-carrying requirements; and its lines to give the greatest speed with a given engine power. It will be admitted that the very able men at the Admiralty and in the dockyards have, as regards both design and execution, raised the ships, as to the hulls, to a high point of efficiency.

2nd. Also as to the armament, as compared with former days, we have now great weight of metal thrown, very destructive projectiles, and immense range.

3rd. The engines: These also are highly efficient. With a minimum of weight they can stand the strain due to the development of the highest horse-power, with an ample margin of strength.

4th: The boilers: Here we have the weak link, the measure of the strength of the whole chain. The highest indicated horse-power can seldom be got, unless forced draught is used with so high an air pressure as to incur serious risk of breaking them down. This is not a matter of doubt but of fact, duly recorded in the daily press.

It should be remembered that there is a very special reason why the boilers should be large enough to supply sufficient steam to drive the engines at the highest power with absolute safety, viz., because the efficiency of the whole ship depends on it. At all times the ship can be handled with ease, and moved from point to point with rapidity; the guns can be effectively fought, and the engines worked with ease and certainty, ONLY while the steam generators—the boilers—remain sound and free from defect. There need be no hesitation in saying that the boilers, instead of being the weakest link in the chain, should be the strongest, and the sooner this is recognised and acted on the sooner we shall obtain a perfect ship of war.

The advocates of the maximum forced draught may say that the adoption of the proposal would involve the giving up of all the benefit we hoped to get from the use of the higher air pressure. Yes, it is so; but the principle of forced draught is still recognised and acted on in the use of the safe air pressure of half-an-inch, which is a great advance on a purely natural draught. What is deprecated is the use of dangerously high air pressures.

A few words more as to the additional weight to be carried if larger boilers be fitted in future battle-ships and cruisers. Ships have now the weight necessary to give the strength in the case of the engines, and *this weight is always carried in the ships.* Is it logical to cut down the size and weight of the boilers so low as to make it unsafe to avail ourselves of the strength and weight we have in the engines?

To conclude: There are, no doubt, some who still hope that forced draught with high air pressures may yet be used with success; but they will probably meet with some disappointment, unless the boilers are made on a different plan to those we have at present. See page 97.

Also, there are those who say that other nations in their war-ships have adopted the forced draught, and are we to give up the benefit to be derived from its use? This question is answered in the preceding remarks; but it may be said further, that it is for the British Navy to endeavour to lead, and not to follow, other nations in all matters which conduce to the production of perfect ships of war.

CHAPTER II.

INDUCED DRAUGHT *v.* FORCED DRAUGHT IN BOILERS.

Brief reference to forced draught in previous chapter—Suggested safe limit —Ships of war should be capable of being steamed under conditions making it absolutely certain that the boilers should not break down under the strain—Therefore, there should be a considerable difference between the highest working strain and the breaking down strain—Induced draught—What is it?—In what does it differ from forced draught?—Description—Not a novel idea—Has been used in the Navy for many years past as the steam blast—Theoretical principle of induced and forced draught the same—Induced draught should have a fair trial under exhaustive and impartial conditions laid down —Evil results of adopting a system or an invention not sufficiently tested by actual experiment—Possible conditions under which both forced and induced draught might be safely used—Attention of engineering firms called to those conditions—Conclusion.

IN the chapter on the use of forced draught in boilers I endeavoured to show what "forced draught" is; how it is obtained; what effect it has on the boilers; why its use above a certain limit causes leakage, and renders the boilers temporarily unserviceable, with a possibility that more or less permanent injury might be done by excessive straining due to using too high an air pressure. Also that the failure of the boilers made necessary a more or less expensive repair, which, while in hand, involved the loss of the ship to the public service.

I also suggested a safe forced draught limit, up to and within which forced draught might be used bene-

ficially, because it would always ensure a very free supply of air necessary for the rapid and perfect combustion of the coal.

But the principal point insisted on was that it was imperative that our ships of war should be capable of being steamed at full power under conditions which would make it absolutely certain, not only that the boilers should not break down under the strain, but that there should be a considerable difference between this highest actual working strain and the breaking down strain. And the limited forced draught suggested, viz., the half-inch air pressure, would provide this difference between the strains, and ensure the continuous safety and efficiency of the boilers.

There is another kind of draught now being experimented on, called "induced draught," and it is claimed for this, that by its use all the advantages gained by forced draught can be obtained without having to pay the penalty of the breakdown of the boilers under the strain. If this can be done, there is no doubt it will be of great advantage to the Navy, and it will, therefore, be well to enquire as to how this induced draught resembles and differs from forced draught, and whether it is probable that the one will succeed where the other fails.

It is understood that the induced draught is obtained by placing at the bottom of the funnels a fan, by the working of which the air is partially exhausted from the uptakes and lower parts of the funnels. This exhaustion of the air causes the air in the boiler-room to be forced in through the ashpits, furnaces, combus-

tion chambers, tubes, and smoke-boxes, into the uptakes, and so up through the funnel. The exhaustion of the air from the uptakes causes a fall in the pressure of the air at this point, and the denser air in the boiler-rooms rushes through the fires, &c., to fill the void, and thus establish equilibrium. But in consequence of the air-exhausting process being continuous, the indraught of air from the boiler-room is also continuous. Thus there is a continuous current of air passing through, and stimulating and forcing the fires, causing intense heat, and generation of steam more or less rapid in proportion to the velocity of the air currents passing through the boilers. This velocity depends on the difference of the air pressure in the boiler-room, viz., the atmospheric pressure, and the air pressure at the bottom of the funnel, whence the air is exhausted. As the difference of the air pressures at these points increases, the velocity of the air currents through the fires increases, the heat generated in the furnaces is more intense, the evaporation of the water more rapid, and the generation of steam quicker. But in what does this differ from forced draught? It is forced draught called by another name. In both cases air fans are used; in forced draught at the stokehold end of the boilers, in this induced draught at the funnel end of the boilers. In both cases the object aimed at is exactly the same, viz., to cause so much difference in the air pressures in the stokeholds and funnels as to make the air rush through the line of fire in the boilers, and out through the funnels. In both cases, the velocity of the air currents through the fires would

cause the "blow-pipe" action on the heating surfaces to be set up. This results in great quantities of steam being given off, which passes through the water, and lifts it away from the plates and tubes, causing over-heating and undue expansion, the contact of the water and the plates not being perfect enough to keep them at a safe temperature.

It may be mentioned here that, before the introduction of forced draught in the Navy, there was always in our ships an induced draught fitting called the steam blast. This was a steam pipe with a regulating valve attached, jointed on to the top of the boilers at one end and to the lower part of the funnel at the other. This steam pipe was carried for three or four feet inside the funnel, and was made to point upward through the centre of the funnel. When the induced draught was required, the blast valve was opened, and a jet of steam was blown with great velocity up the funnel. This caused the exhaustion of the air at the bottom of the funnels and the in-draught of the air from the stokeholds through the fires, causing them to be "forced" to a degree proportional to the velocity of the air currents going through the fires. The break-down of boilers in those days were much fewer than in these, but of those that did occur quite 70 per cent. were caused by the use of this steam-blast-induced draught. But as the breakdowns were fewer, it may be asked whether this does not prove that the steam-blast-induced draught is better than the forced draught, in the sense of doing less injury to the boilers. The answer is, No; for the reason the boilers did not

break down with the use of the steam-blast-induced draught so often as at present with the forced draught, is that the draught with the former was never as great as with the latter. In other words, when working at the highest power, in both cases the fires could not be *forced* by the steam blast to the same extent as with forced draught; it is the undue forcing of the fires by the use of an excessive draught which causes injury to the boilers. When the use of the steam blast caused leakage, it was nearly always found that a scale had formed on the heating surfaces inside the boilers, so that the heat could not be readily transmitted through this scale to the water, and that in consequence the plates and tubes could not be kept at a safe temperature. With boilers in this condition, the full steam-blast-induced draught was excessive, for with the use of a moderate blast, or a purely natural draught, no injury was done. With new and clean boilers the use of the steam blast very seldom caused leakage.

From the above description it will be seen that there is no novelty in the idea of an induced draught by the exhaustion of the air from the lower part of the funnels. In the case now being considered, the novelty is the fitting a fan at the bottom of the funnels for the purpose of exhausting the air at that point, and it would appear that exactly the same thing was done by the steam blast, the excessive use of which was found, as has been mentioned, to have an injurious effect on the boilers.

By the foregoing it would appear that, theoretically, there is no difference in principle between the two cases of induced draught and forced draught. The

object aimed at is the rapid generation of steam, by the forcing of the fires, which is done in all these cases in exactly the same way, viz., by driving air with more or less velocity through the fires, causing the generation of intense heat over the whole of the heating surface. This heat depends on the velocity of the air currents driven through the fires. Lastly, but most important of all points in the consideration of this subject, in all these cases of either induced or forced draughts the velocity of the air currents through the fires is governed by one and the same thing, viz., *the difference of the air pressures at the points of ingress and egress;* ingress at the furnace and egress at the funnel end of the boilers.

This being so, and similar causes producing similar effects, the question arises: Why should forced draught and the steam-blast-induced draught act injuriously on marine boilers, and the induced draught caused by the fan at the bottom of the funnel not do so? For, apparently, the action on the boilers is the same.

No doubt the induced draught now being considered deserves a fair trial. Any invention that, when tried, will stand the test of experiment, and do what it is intended to do, may be regarded as successful. On the contrary, any invention that will not stand the experimental test is not only useless, but misleading and dangerous. An illustration of this has occurred in one or two ships in which, when on trial under forced draught, the boilers have given out so suddenly and completely as to cause the death of some and serious injury to others by burning or scalding, these break-

downs occurring when there was no apparent shortness of water in the boilers. This is an element in the case which should not be lost sight of, viz., the possibility of danger to life or limb by the use of an excessive draught, whether forced or induced.

Before the superiority of this induced draught to forced draught can be proved, it would be necessary to give it a trial under the same circumstances and conditions as the forced draught, and if possible in the same ship, and with the same boilers; the trial should be continued not only up to the point where the forced draught broke the boilers down, but till the full specified contract indicated horse-power be obtained; this would prove that the induced draught could do what up to the present the forced draught has failed to do, as, *e.g.*, in the *Barham* and *Seagull* classes of ships. The trials should be of sufficient length to determine whether the boilers would remain continually efficient under the test, and be witnessed by impartial officials, who would not be influenced by the natural optimism of the inventor. These precautions are necessary, and will prevent a too hasty adoption of an invention which has not been sufficiently tried. It must be remembered that inventors' and contractors' trials are not final trials of the machinery of Her Majesty's ships. The final trials will be the full-power runs, periodically made during the future life of the ships, which will inevitably show any failure to come up to the requirements. There have been several cases, for instance, of new ships having gone through the four hours' forced-draught contractors' trial satisfactorily, yet very early after commis-

sioning the boilers have broken down badly. The fact is, that it is only while the boilers are quite *clean*—as in the case of new boilers—that forced-draught trials can be made with satisfactory results, and not always then ; and it is equally true that the longer boilers are in use, the less clean they are, and the less fit to be worked under forced draught.

There is little doubt that both forced and induced draught might with safety be used to a much greater extent than can be done at present, if certain things could be done, as, for example :—

1. If the formation of incrustation and scale on the water side of the plates and tubes constituting the heating surface of the boilers could be prevented, so that there might be perfect conduction of heat through the clean plates.

2. If the boilers were designed to ensure a good circulation of the water in them, over, around, and about all parts of the heating surface, and to maintain perfect *contact* between the *water and plates* at the time the generation of steam is most rapid.

Engineers appear to have brought all their skill to bear on perfecting the arrangements and fittings of the outside, or what might be called the fire side of the boilers, whereas it is evident, if the assumptions in 1 and 2 be correct, that the arrangements, &c., of the inside, or water side of the boilers, require much improvement; and it would be well to note this, for it is in this direction that the remedies for existing evils preventing the safe development of boiler power will probably be found.

CHAPTER III.

FURTHER REMARKS ON FORCED AND INDUCED DRAUGHT IN BOILERS OF WAR-SHIPS.

Reference to the two foregoing chapters—Alteration in designs of boilers during the past two years—Faulty designs of some modern boilers—Fitted in *Blake—Vulcan*, *Thunderer*, Success of *Royal Sovereign* except in one respect—Reasons why the leakage of boilers under forced draught always increases and never diminishes—Cases of new and old boilers considered—Difficulty of removing scale from parts of heating surface—Case of a new, well-designed and constructed boiler considered—The "boiler difficulty"—What is it?—How has it been caused?—Is there any real boiler difficulty?—If so, a simple way of causing it to vanish—The real boiler difficulty—Designing boilers that will safely work under forced draught, with the use of high air pressures—General principles on which the designs of such boilers should be based—Fully considered—Designs of the water side of boilers require improvement—Instances of cobbling at the fire side of boilers—Consequent failures—Present tests of boilers not sufficient to ensure continuous efficiency at sea—Four hours' full-power trial under favourable circumstances not enough—Reference made to endeavour to improve circulation of water in boilers—Failure in present types—Mr. Thorneycroft's boiler—Designed on sound principles—Expected drawbacks—The three special points to be kept in view in designing boilers—Reasons for the strictest limitation of the maximum forced draught—Fleet evolutions—Problems for solution—Forced draught trials with high air pressures no longer allowed with present types of boilers—Remarks on new inventions and inventors—Necessity of severe and exhaustive trial of new inventions before adoption in Her Majesty's service—Nature of test—Duration—For fixing limit of breaking down strain—Working limit to be fixed well within the danger limit—Results in detail of the adoption of this mode of trial—Necessity of proceeding on safe lines in matters vitally affecting the efficiency of the Navy, and the welfare of the nation.

THE two preceding chapters were published in one of the leading Service journals more than two years ago.* Since that time many changes have been made in the boilers fitted to Her Majesty's ships, and nearly all these changes are in the direction recommended in those chapters. For example, there is now in nearly every case ample space assigned in new ships for engines and boilers, also the boilers are of such a size, weight, and strength, as to be capable of generating sufficient steam at the required pressure to drive the engines at the highest speed, and develop the maximum contract horse-power, under forced draught, with very moderate air pressures, varying from ·4 in. to 1·2 in.; that is from about half-an-inch to one and a quarter inches. But the latter cases are rare, and the average air pressure now used in modern ships on full-power forced draught trials is ·7 in., or less than three-quarters of an inch. With such a limited air pressure, it is almost needless to say that we seldom, if ever, hear of any breakdown of new boilers under trial. There have been indeed cases in which the use of even this moderate air pressure, has caused the breakdown of the boilers, as *e.g.*, the *Vulcan*, *Thunderer*, *Blake*, and some others. But this is clearly traceable to the boilers being so faulty in design, as to make it unsafe to work them with what, in other cases, would be a moderate and safe air pressure.

There are not wanted cases in modern ships which fully verify the truth of the arguments in the chapter on Forced Draught.

* *Illustrated Naval and Military Magazine*, July, October, 1890.

Take the *Royal Sovereign*, a vessel which reflects the highest credit on the Naval Construction staff, both at the Admiralty and at the Dockyard where the ship was built. The rapidity and cost of construction, and excellence of workmanship, make the ship, in those respects, a phenomenal one as regards the approximation to the ideally perfect type of a modern war-ship. But in this ship the boilers were, presumably, too small to do the work of driving the engines at the highest rate of speed necessary to develop the maximum contract horse-power under forced draught. I say the boilers were *presumably* too small, because to get the maximum horse-power an air pressure of one and a half inches had to be used, and what was the result, as reported in the press? That everything went well for the first three hours—an old story—but that during the fourth, and last hour of the trial, the tubes of two boilers began to leak, causing a considerable drop of the horse-power, so the particulars of the first three hours of the four hours' trial were taken to calculate the average results. This proves that the air pressure used reached a point at which the strain on the boilers was dangerously near the breaking-down strain. It was, in fact, leaving the absolutely safe limit, and very nearly approaching the unsafe. In this connection it may be well to quote a paragraph in the chapter on forced draught. "It is part of the alphabet of engineering science, that to insure the safety of any structure or piece of machinery, there must be a very considerable difference between the *highest actual working strain* and the *breaking (down) strain*, and the half-inch limit is suggested, as

giving the difference that will ensure the safety." And, again, "Any departure from this safe limit is an approach to the unsafe." I need not point out how thoroughly this was verified in the case of the *Royal Sovereign*. Had the trial been continued with the same air pressure, there can be no doubt that in two or three hours all the boilers would have given way, and leaked badly, as scores of others have done under similar circumstances. When on a forced draught trial the tubes of the boilers begin to leak, it is well known by experienced engineers that, under the same strain, the leakage never diminishes, but always increases, and for a very simple reason—all tubes are stays for the tube plates, but when a tube leaks, *i.e.*, when it moves in the plate, it ceases to be a stay, and therefore the parts of the tube plates in the vicinity of the leaky tubes are to some extent unstayed, and the high temperature, and the enormous internal pressure, cause the *springing* of the tube plates between the stay tubes. This causes the tubes to work in the plates, and brings on rapidly a very general leakage of the tubes.

It is beginning to be pretty well understood, even by the greatest faddists among the advocates of forced draught, that *with boilers designed as at present*, it is unsafe to exceed a limit of three-quarter inch of air pressure, even in the case of *new boilers*. I say new boilers, because, unfortunately, boilers do not long remain new; and it is partly for this reason that I suggest the half-inch limit of air pressure as that which it is unwise to exceed. By use boilers will, in the course of time—very soon if any sea-water "make up" be used—get a scale on the

water side of the plates and tubes which form the heating surface. This scale can be readily cleaned off from many of these parts, but it so happens that the parts where its accumulation is most dangerous, viz., the water side of the fire-box tube plates, and the ends of the tubes in them, are most difficult, and almost impossible, to thoroughly clean. Indeed, in many cases, it has been found necessary to draw the tubes for the sole purpose of cleaning the scale off them and the fire-box tube plates. This is an expensive process, and, moreover, it causes the detachment of the ships from the service of the fleet while the work is being done. Of course, with care, the accumulation of scale can, to a great extent, be prevented, but I doubt whether its formation can be entirely stopped, even by the most careful management.

A well designed and constructed boiler of the present type when new, and therefore quite clean, would, probably, on a full-power trial, stand an air pressure of one inch without causing tube leakage; but it is well known by experienced sea-going engineers that this same boiler, with only *one-sixteenth* of an inch scale on the fire-box tube plate, would, undoubtedly, break down with the use of this one-inch air pressure; but the same boiler might be safely worked with half-inch. Boilers should be made, not only to go successfully through a *four hours' full-power trial,* but to steam our ships at full power, under safe conditions, at any time during a *four years' commission.* And for this reason, as well as others, I would advocate the fitting of boilers capable, with the use of a moderate air pressure, of steaming at the

full engine power, which will ensure that the high speed thus obtained will be an ocean passage speed, and not, as in many cases at present, a four hours' full power "*spurt*" speed.

A phrase has been recently invented, and very much used by the Press, which possibly, to the lay mind, has a deep and obscure meaning. This phrase is, "The Boiler Difficulty." Now is there such a thing as "the boiler difficulty"? If so, what is it, and how has it been caused? If any experienced sea-going engineer were asked these questions he would at once say there was no such difficulty existing as "the boiler difficulty." There is, indeed, one difficulty, viz., the difficulty of making boilers stand, without breaking down, a strain that they cannot possibly stand.

This is a difficulty that will never be surmounted. It is probable that no engineer of experience and ability would, for a moment, admit that there is anything that can be in truth called a boiler difficulty. Therefore we may ask, How has this so-called "boiler difficulty" been caused? It has been caused, apparently, by the utter failure of a certain type of boiler to stand a strain which many other types of boilers have stood with safety. But, because one type of boiler has failed to bear an ordinary strain, does it cause a boiler difficulty? Obviously the way to remedy this in future designs of boilers is to carefully avoid the special points—they are well known—which caused the failure. And there the boiler difficulty appears to end, for in no other cases have any boilers failed, on trial, to meet the requirements, except when under an excessive forced draught,

produced by the use of high air pressures, they have broken down under the strain; that is to say, they have failed to stand a strain that they could not possibly stand, and that they could not reasonably be expected to stand. These remarks apply, of course, only to the types of boilers fitted up to the present time in Her Majesty's ships. As to these, I repeat that there is no "boiler difficulty," except that of making them stand a strain which no competent professional engineer of experience would ever expect them to bear safely; and this difficulty vanishes directly the air pressure is reduced to such a point as to enable a boiler to be steamed *continuously* without breaking down.

But there *is* a difficulty, and a very great one, if it be considered necessary and possible to design future boilers on a plan that would ensure them being worked safely, under forced draught, with high air pressures, thus economising the weight carried and the space occupied in our ships. It would perhaps be profitable to endeavour to lay down some general principles on which the designs of these boilers should be based.

In the chapter on "Induced Draught versus Forced Draught" I ventured to say that our great engineering firms would do well if they paid special attention to certain points in boiler design and construction. The paragraph will bear repetition here:—

"There is little doubt that both forced and induced draught might, with safety, be used to a much greater extent than at present if certain things could be done, as for example:—

"1. If the formation of incrustation and scale on

the water side of the plates and tubes constituting the heating surface of the boilers could be (wholly) prevented, so that there might be perfect conduction of heat through the clean plates" (to the water).

"2. If boilers were designed to ensure a good circulation of the water in them, over, around, and about all parts of the heating surface, and thus to maintain perfect contact between the water and plates at the time the generation of steam is most rapid." It is then added: "Engineers appear to have brought all their skill to bear on perfecting the arrangements and fittings of the *outside*, or what might be called the fire side of the boilers, whereas it is evident, if the assumptions in 1 and 2 be correct, that the arrangements, &c., of the *inside*, or water side, of the boilers require much improvement; and it would be well to note this, for it is *in this direction* that the remedies for existing evils, preventing the safe development of boiler power, will probably be found."

Though published more than two years ago, the above is as true in these days as in those. Perhaps, however, some benefit will be obtained by expanding the ideas contained in 1 and 2, but I would first remark that I do not believe there are many engineers who would question the truth of the propositions in those paragraphs; in fact, it is probable that all experienced men would agree that if *perfect contact* between the water and the plates could at all times be maintained,

the plates and tubes would be kept at a safe temperature, and the boilers would not break down, even with the use of higher air pressures.

As to paragraphs 1 and 2, just quoted from the chapter on Induced Draught; there can be little doubt that all cases of the breaking down of boilers, by excessive leakage, when under forced draught, have been caused mainly, if not wholly, by two things:

a. By the imperfect contact between the water and plates and tubes, at the time the generation of steam was most rapid, caused by insufficient water space between the tubes, and the enormous quantity of steam given off, and passing through the water, lifting it away from the heating surfaces, and consequent thereon.

b. The great increase of the temperature of the plates and tubes, causing an abnormal expansion, and the forcing of the tubes through the tube plates when in the over-heated condition.

No doubt there is some repetition here of parts of the paper on Forced Draught, but it is necessary, as will be seen later, to prove that boilers at present are faulty in design, and also to state on what principle they should be designed if intended to be worked under forced draught with high air pressures.

There is, and always will be, a considerable difference between the temperatures of various parts of a boiler, when steamed under forced draught, as, for example, between the parts along the line of fire, viz., furnaces, combustion chambers, and tubes; and the outside shell. For instance, take the tube plates, they are rigidly

stayed to each other by stay tubes, about three times thicker than the ordinary tubes. Now, in ordinary boilers, with small water spaces between the tubes, when the generation of steam is very rapid, due to the use of a forced draught with a high air pressure, there is probably a considerable difference in the expansion of the stay and ordinary tubes; and if this exceeds a certain limit, one of two things must happen, either the parts of the fire-box tube plate, between the stays, will spring, and so take up the difference between the expansion of the stay and ordinary tubes, or the latter will force their way through the holes in the plate, and so bring on the leakage which breaks the boiler down.

From this it will be seen, that, as regards the designs of boilers intended to be worked under forced draught, two special points should be attended to, and this is suggested for the consideration of professional men, engine makers, and others. These two points are:

1. The provision of ample water space between the tubes, so as to ensure the free circulation of the water, and the maintenance of the contact between it, and the tubes, and tube plates; and
2. The provision of means for the "taking up" of the expansion, due to the difference of the temperatures of the various parts, so that there might be no undue strain on parts of the boilers tending to break the joints of the tubes in the tube plates, or those of the rivetted seams.

I do not think enough attention is paid to these points. As regards the designs of boilers, we seem to have got into a groove out of which it is difficult and almost

impossible to get. Indeed, sometimes, instead of progressing, we seem actually to go back. Hence we see that in consequence of not sufficiently considering the two special points mentioned, several boilers, such as those of the *Thunderer*, the *Blake*, the *Vulcan*, and some others, have actually broken down, even with the use of a very limited forced draught, such as has been safely used in many other boilers of a different design.

It will be noticed that the two special points suggested for consideration in the designs of boilers, are chiefly aimed at the improvement of the arrangements and fittings of the *inside* or *water side* of the boilers, and I presume few engineers would dispute the soundness of my prediction in the chapter on Induced Draught, viz., that "it is in this direction that the remedies for existing evils, preventing the safe development of boiler power, will probably be found."

Nevertheless, it is a singular circumstance, that during the two years that have passed since that was published, engineers seem, to some extent, to have ignored the idea of perfecting the water side, but have devoted attention to what many would consider "cobbling" the fire side of boilers.

Some years ago, when on forced draught trials at full power, there were more failures than successes, there were several instances of "cobbling" at the fire side of boilers, in order to get through a four hours' full-power trial without breaking down. One of these was to plaster cement on the fire-box tube plates to prevent their being over-heated. This "cobbling" was of

course a failure, as every one experienced in sea-going engineering knew it would be, for in a very short time, such as one day of hard steaming, the cement would fall off the parts of the tube plates, on which the flame impinged, leaving unprotected the very parts which required most protection. The last state of that boiler would be worse than the first.

Another "cobbling" device was fitting thin iron covering plates over the riveted seams of the combustion chambers, which sometimes gave way under the very high temperature, and the great strain to which they were subjected. As in the former case, one day's hard steaming would dispose of these plates, for as it was not possible to fit them so well, as to ensure protection from the high temperature, by the water in the boiler, they soon burned through, and became useless, leaving the seams as unprotected as before. It may be remarked here that these cobbling devices seemed to be invented chiefly for the purpose of causing boilers under forced draught to go safely through a four hours' full-power trial, and it must be admitted, in some instances, with more or less success, but very much more than this is wanted, as will be seen by-and-bye.

There has been invented, quite recently, a tube ferrule, which certain enthusiastic people, mostly writers to the newspapers, very much praise; and some of them state that it is so good a thing that it will probably overcome the "boiler difficulty." Now many experienced sea-going engineers have had to do with several sorts of boiler tube ferrules, with the result that they look rather suspiciously on a new invention, and will not be sure of

its excellence unless it be tested by actual experiment in such a way as to decide that it is good, not only for a four hours' full-power trial, but *for continuous service at sea.* Many of these men would probably consider the application of this ferrule as only another attempt to "cobble" the fire side of a boiler, and some reasons will be given by-and-bye in support of this opinion; meanwhile, as described in the Press notices, this is a ferrule which, when driven into the fire-box ends of the tubes, protects them and the tube plates from the action of the flame, thus preventing the overheating that brings on leakage. The question to be answered is this: Will the use of this ferrule make the boilers capable of being steamed under a forced draught with a higher air pressure than that now used, and remain *continuously efficient at sea?* The chief excellence of this ferrule is said to be, that, when driven into the fire-box ends of the tubes, it covers over, and so protects the tube ends and plates exposed to the direct action of the flame. The ferrules are driven a little distance into the tubes, and are described as being so made as to admit of there being a *clear space,* for a short distance, between the ferrule and the tube it protects. Now this will necessitate this ferrule being thicker than the ordinary ferrule, and, therefore, will materially decrease the tube area through which the smoke and flame pass. This is a drawback, but not the chief one; for, there being a clear space between the tube and the ferrule, the latter will not be protected by contact with the tube and the water in the boiler, and therefore the ends of the ferrules may be expected to rapidly burn off if subjected beyond a limited

time to the temperature due to the use of a forced draught with a moderately high air pressure. This would be caused by the fact that the part of the ferrule on which the flame impinges is necessarily the thinnest, and, as has been said, is unprotected by the water in the boilers. There is no doubt that, by the use of this ferrule, boilers might safely go through a forced draught trial with the use of a much higher air pressure than could otherwise be used, and not only *one* forced draught trial of four hours duration, but several of these trials; nevertheless it is contended that each of these spells under the maximum forced draught will do its part towards burning through the ferrules, and there will come a time when they will be completely burned through, and the ends will fall off, especially the ends of the ferrules at those parts of the tube plates where the impinging flame is the fiercest. Should this happen, the parts of the tube plates which require most protection would be as unprotected as before; added to which the boilers would further suffer by having a hollow plug fixed in the fire-box end of every one of the tubes, and so restricting the tube area, and checking the passage of the flame through the boiler, thus increasing the local heat in the fire-boxes and combustion chambers, which, before the application of the ferrules, was already so great as to cause the breakdown of the boilers. Therefore may not this be described as a kind of cobbling at the fire side of a boiler in order to counteract the effect produced by the radically faulty design of the water side?

It is true that the *Thunderer* is reported to have

steamed with the use of these ferrules to Madeira and back at four-fifths of the full natural draught power, which could not have been done without the ferrules. But this ship's boilers are of faulty design, and have failed to do what has been safely done by ordinary boilers of a different kind. Great credit is due to the inventor of this ferrule because, by its means, the boilers of the *Thunderer* and all similar boilers will be able to do what could otherwise not be done. But surely all ordinary boilers of a better design than those of the *Thunderer* kind should be capable of being steamed at four-fifths of full power a distance of over 2,000 miles without breaking down, and with *the full tube area, i.e.*, without the restriction of the tube area caused by ferruling.

What is contended here is, that the fittings of the boilers should be such as to ensure *continuous* efficiency at sea. These ferrules, for example, will be temporarily efficient for the purpose of preventing the leakage of boilers; but will they be *permanently, continuously,* efficient for service at sea? If, for instance, as is contended, these ferrules will be always getting thinner, causing at last the ends to drop off altogether, can they be said to ensure continuous efficiency? Is not the fitting of them a kind of temporary makeshift, which conceivably may fail in *the hour of need?* Most assuredly these ferrules will burn through, and become useless after several spells of hard steaming under the maximum forced draught, and the boilers will then be left as unprotected as before, perhaps at the very time they will be required to be most efficient. Would it be wise

to consider that the boiler difficulty has been overcome by this invention?

What is wanted in the Navy is, that the machinery and boilers of our war-ships shall be designed and made so as to be efficient for actual and continuous service at sea. It would be much wiser to attempt to improve the general designs of boilers, with a view to ensuring this continuous efficiency, than to adopt expedients that appear to be of a temporary and makeshift character. In any case new inventions should be severely tested. Here a paragraph in the chapter on "Induced Draught" might be quoted:—

"Precautions are necessary in order to prevent a too hasty adoption of inventions which have not been sufficiently tried. . . . . . . Inventors' and contractors' trials are not final trials of the machinery of Her Majesty's ships. The final trials will be the full power runs, periodically made during the future life of the ships, which will inevitably show any failure to come up to the requirements."

It would be wrong not to recognise that, as regards the present types of boilers which have failed to go through the maximum forced draught trial, an honest attempt has been made to do what is wanted more than anything else, or, indeed, more than all else together, viz., to improve the circulation of the water in the boilers, and thereby keeping more perfectly the contact between the water and tubes and plates. For instance, the water spaces have been increased by the removal of some of the tubes, but this can be done only to a limited extent, and even then with a serious loss of

heating surface, for it is obvious that to effectively increase the water spaces, 30 or 40 per cent. of the tubes would have to be removed, and, of course, this would simply ruin the boilers as steam generators. A much better way of increasing the water spaces in the designs of new boilers would be to have tubes of a larger size than the present ones.

It is said that Mr. Thornycroft has designed a boiler that is expected to do what the ordinary type of boiler has always failed to do, viz., to work safely under forced draught with high air pressures, and that he proposes to do this by improving the design of the water side of the boiler. If so a great advance will be made, not by cobbling, but by going to the root of the matter. The statement of the means by which the effect will be produced has a wholesome sound and promises well. I do not wish to be a pessimist, but, as a sea-going engineer, I shall look for drawbacks. For example, will there be ample facilities for thoroughly cleaning the inside or water side and the outside or fire side of this boiler? For these facilities are absolutely necessary. Also, Will the boiler be so designed as to prevent the smoke-boxes and uptakes, when working with the maximum air pressure, being injured by becoming red-hot or even hotter?

In concluding this chapter it would be of advantage to repeat a statement already made, and which I confidently submit as the result of experience and observation. In designing boilers intended to be worked under forced draught with high air pressures three special points *must* be kept steadily in view.

1. That it is necessary to provide for the maintenance of perfect contact between the water and the plates and tubes *when the generation of steam is most rapid.*

2. That, considering the very great heat along the line of fire, viz., the furnaces, combustion chambers, and tubes, it is necessary to make provision whereby the great expansion and contraction, due to the variation of temperature, might take place without injury to the boilers.

3. That provision should be made whereby the heat generated in the furnaces might be evenly diffused and distributed over all parts of the heating surface, *i.e.*, that every square inch of the heating surface shall, as far as possible, contribute equally to the generation of steam.

As to this last point. In all boilers made up to the present time the greatest heat is localised in the combustion chambers, and those parts of the heating surface in their immediate vicinity have much the greater share of the work to do in the generation of steam. It is probable that very little of this work is done by quite three-fourths of the length of the tubes, measuring from the smoke-box end, though this portion of the tubes forms a very considerable fraction of the total heating surface. Could this part be made to do more, and the other parts of the heating surface less, the heat would be more evenly distributed, every part would do its fair share of work, and the result would tend to the preservation of

the boiler from injury by the overheating of certain parts.

There can be little doubt that these three special points have not been sufficiently considered in the designs of boilers; and to this may be attributed, not only the many mishaps which have occurred when working under forced draught, but also the fact that, at the present time, there are many of Her Majesty's ships fitted with boilers that cannot safely do all they were designed to do. This is the real boiler difficulty, which I submit, with some confidence, will only be surmounted by making the provisions specified in 1, 2, and 3.

If this can be done in the designs of future boilers it is probable that they will be capable of being worked under forced draught with a much higher air pressure than can be safely used with the present types of boilers. But any invention professing to do this should be impartially, thoroughly, and even *severely* tested *by actual experiment,* not only for a few hours off a port, under the most favourable circumstances, but at sea, when cruising with a fleet or making passages, and with occasional runs at the maximum forced draught power, of not less than twelve nor more than twenty-four hours' duration. A better test still would be for one ship to run at full power under this increased forced draught to Gibraltar and back, for this would settle beyond all doubt the question whether the boilers could be so steamed, *i.e.*, continuously, without breaking down. This would be actual experimental proof of the utility and safety of any boilers designed to work with forced draught with the use of a high air pressure.

At present the use of what might be called the maximum forced draught is strictly limited, and this is wise for three reasons. 1. Because the general service does not require the highest rate of speed except on very rare occasions. 2. Because it would be unwise to subject the boilers to so great a strain *unnecessarily*. 3. Because the consumption of coal would be so great as very soon to exhaust the supply, and so reduce the coal endurance to the lowest possible limit. Therefore it is wise to make the severest limitation of the use of the maximum forced draught. But this limit should not be imposed *because of a fear lest the boilers should break down*, for if so, forced draught would be a sham and a very dangerous sham. Ships might, for example, become useless at the very time they are required to be most efficient, viz., when chasing the enemy or in action, at which times the use of a *safe* maximum forced draught would be of the greatest advantage, giving us, in fact, the weather-gauge of the enemy. Under such circumstances it is, to my mind, of the utmost importance that any maximum forced draught should be that, the use of which would be *absolutely* safe; and to ensure this the air pressure in every case should be such as to make a very "considerable difference between the *highest actual working strain* on the boilers and the *breaking down strain*." This applies to all boilers; to those which in the past have failed to do what they were designed to do, and to those which, in the future, may be designed for the use of a much higher forced draught than can be used in our present boilers.

As every evolution of a fleet is now carried out under

steam it is of the greatest importance that the steam machinery should always be in a state of the highest efficiency, and this is especially the case as regards the boilers, *i.e.*, the steam generators ; and although to the lay mind the subject is probably dry and uninteresting, it is to professional men, and to naval men especially, a subject of absorbing interest. To be able to work the boilers so as to get the greatest possible amount of work out of them, *under absolutely safe conditions ;* to do this with the minimum weight of material, and the occupation of the least possible space in the ships ; to so arrange as to make it practically and easily workable ; to be able to work at this maximum power, not for a few hours only, but for days, if required to make rapid passages, or for any length of time when evolutionising in a time of war, in pursuit of or in action with the enemy : these are problems well worthy of attempt at solution by our ablest professional men, who will be well rewarded if they meet with only a measure of success. I have endeavoured to lay down a few general principles on which the designs of boilers should be based, if intended to be worked under forced draught, with the use of high air pressures. I submit these with some confidence, as the result of a large personal experience of forced draught trials with boilers of all kinds. It was no uncommon thing to see, some time back, a new ship, with new strong boilers, go out of port into the Channel for a full-power forced draught trial, with the use of any air pressure up to, but not beyond, two inches ; and the return into port, three hours after, with all

the boilers leaking; dancing along, when going out, at a speed of 16 knots, and crawling back at a speed of 7 knots. This, happily, is no longer the case, trials with high air pressures being now wisely disallowed with the present types of boilers.

As regards the inventors of future boilers, it is well to remember that inventors are naturally, like converts, enthusiasts; therefore we must allow a liberal discount when observing their optimism, and, indeed, in such a matter as this, viz., the adoption of a new type of boiler which is to do what has never yet been done, it will be necessary to test it severely by actual experiment, "in the presence of impartial officials, the trials to be of sufficient length to determine whether the boilers would remain continually efficient under the test." In fact, it would be well to test in the case of one ship, and one set of boilers right up to their *complete breakdown*, in order to fix the *danger point*, and *well within* this point should be fixed the safe working limit of strain, which should on no account ever be exceeded. In this way any new type of boiler could be tested, and the limit of safe working strain fixed, and thereafter boilers of the same type might be fitted in Her Majesty's ships, with an absolute certainty that forced draught, up to the prescribed limit, could be used with ease and safety. The adoption of this plan would make it impossible for our ships of war ever again to be fitted with boilers which, on trial, would fail to do what they were designed to do; it would ensure safety and efficiency; it would give our Admirals, Captains,

and other officers, a confidence in their ships and machinery, which must have been more or less wanting for some years past; and above all, we should proceed on safe lines in a matter nearly and vitally affecting the efficiency of the Navy and the interests of the Nation.

CHAPTER IV.

MODERN MARINE ENGINES.

Changes brought about by the adoption of the triple expansion type of engines in war-ships—Improvement in the coal endurance—Reasons for this—Description of this type of engines—One cylinder only, and that the smallest of the three, filled with steam from the boilers—Surface condensation of the steam—Description showing why it causes an economical consumption of coal—Comparison between "jet" and "surface" condensers—Principle on which is based the equalisation of power developed in the cylinders of a set of triple expansion engines—Definition of technical terms—Balance of power of engines not the same at all rates of speed—Reasons—How this balance can be retained up to certain limits—Has the Navy benefited in every way by the adoption of triple expansion and surface condensation?—No—Drawbacks—High pressure steam—Strong boilers required, necessitating great weight to be carried in our ships, and assignment of ample space—How these wants have been met—Forced draught—Illustration—Limitation of working strain to ensure safety—On what principle should this limitation be made?—Reference to great achievements in engineering—Drawbacks in connection with the engines—At low rates of speed two engines do all the work, the third engine either doing nothing, or being pulled round by the two—Possibility of this useless engine being quickly disconnected when it causes a waste of engine power—Methods of doing this proposed—Illustration of the great variation of engine power at different rates of speed of ship as shown by the actual performances of a first-class cruiser, *Edgar* class—Showing that at all rates of speed below the ordinary cruising speed, viz., 7 to 12 knots, the low pressure engine would be a drag on the others—This drawback not felt in mail steamers—Discussion as to which of the three cylinders it would be best to disconnect—Reasons given—Conversion of triple expansion into pairs of compound engines—Estimated results as affecting speed in knots—Full power always required in a time of war—Concluding remarks.

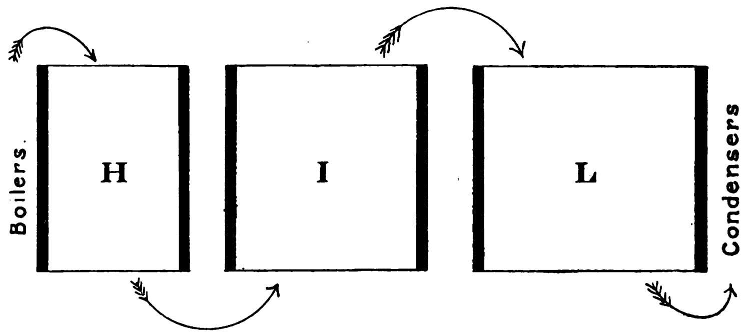
THE adoption of the triple expansion type of engines in our modern war-ships has resulted in a very marked improvement as regards the economical consumption of coal, and thereby improved

the coal endurance, *i.e.*, considerably increased the time during which our ships are efficient at sea, so far as the coal stowage is concerned. This improvement in the economical consumption of coal may be easily seen by the fact that, in former days, with the old type of common engines then in use, the coal consumption per indicated horse-power per hour, varied from 3 to 5 and even 6 lbs. We may with certainty take the mean consumption at 4 lbs. of coal per indicated horse-power per hour with the old engines.

Now, with the modern triple expansion engines, the consumption of coal varies from $1\frac{1}{4}$ lbs. to $2\frac{1}{2}$ lbs., and the mean might be fixed at about 2 lbs. per indicated horse-power per hour. So that the consumption of coal with the modern as compared with the old type of engines is as 2 to 4, or as nearly half as possible. This is calculating the coal consumption when working at full power in both cases. The difference would probably not be so great when working at any lower power, but it would be very considerable at all rates of speed.

The reasons why the use of the triple expansion type of engines has resulted in so economical an expenditure of coal, are well known to professional men, but for the information of others it may be well to state briefly and simply some explanation of this.

In triple expansion engines there are three cylinders to every set of engines; these cylinders are of the same length but of different diameters, as shown in the diagrams.



Here H is the high pressure cylinder.
And I is the intermediate cylinder.
And L is the low pressure cylinder.

Roughly the arrows show the progress of the steam from the time it leaves the boilers till it passes into the condensers.

It will be seen that H, the high pressure cylinder, alone receives steam direct from the boilers ; that after this steam has done its work in H it passes into I, the intermediate cylinder ; and that when it has done its work there it again passes into L, the low pressure cylinder, whence it finally passes into the condensers, where it is condensed, and pumped as fresh water back into the boilers.

Thus, in triple expansion engines, the boilers have to supply steam to *only one,* and that the smallest of every set of three engines, whereas in former days, with the common engines, *all* the cylinders had to be filled direct from the boilers and with steam of comparatively low pressure. In these days, with modern engines, very high pressure steam fills the small high pressure cylinder H, and, continually expanding, passes into and

through the two larger cylinders. But as the steam pressure varies inversely as the space it occupies, the expansion of the steam into the increased spaces in I and L, the intermediate and low pressure cylinders, causes a continual fall in the pressure, so much so that, very frequently, the steam which enters the high pressure cylinder at a boiler pressure say of 150 lbs. on the square inch, falls by continual expansion into the larger spaces I and L to only a little above zero by the time it is exhausted into the condensers. Thus the economical consumption of coal is caused chiefly by the principle of the expansion of the steam being applied and carried out to its fullest extent. It might be thought that as, in the supposed cases of the old and modern types of engines, three cylinders in one case and one cylinder in the other, have to be supplied with steam direct from the boilers, the coal consumed in the two cases would be as 3 is to 1; but this is not so, because in the old type of engines the principle of expansion was always carried out to a limited extent by the cutting off of the steam in every cylinder before the end of the stroke of the piston, and coal was economised to some extent by this limited expansion of the steam.*

It should be stated here that economy in coal consumption in modern engines is also caused by the surface condensation of the steam. This has nothing to do with triple expansion, because surface condensation can be applied in the case of compound or even

* For purposes of comparison, it is assumed that the old type of engines cited have three cylinders.

common engines. Perhaps it will be well to give a brief description of a Surface Condenser. It is a large chamber in which are fitted a large number of thin metal tubes, fitted water-tight at both ends into tube plates. The whole chamber is divided into two spaces; on one side of the tubes is the water space, on the other side the steam space; through the water space a current of cold sea water passes by the action of small engines called circulating engines, and this current of sea water keeps the thin metal tubes cold. When the steam, after doing its work in the cylinders, passes into the condensers, it comes into contact with the cold metal tubes on the steam side of them, and is immediately condensed, becomes fresh water, and is pumped by the feed engines into the boilers. Now the accumulation of the saline scale on the heating surfaces of the boilers, on the water side, is one of the most fruitful causes of a wasteful expenditure of coal; but none of this scale can be deposited by the use of fresh water, and consequently the boilers, being fed with fresh water from the surface condensers, are kept clean and retain continually their full steam generating power. In former days marine engines were fitted with what were called jet condensers, which were simply large chambers, in which the steam was condensed by and mixed with the sea water. A portion of this brackish water, which was pumped into the boilers at a low temperature, had to be blown out into the sea to prevent it becoming too salt and causing a deposition of scale on the heating surfaces. The coal consumed in heating this water so blown into the sea is now entirely saved by the use of

fresh water from surface condensation and double distillation. Thus it will be seen that surface condensation causes a considerable part of the saving in coal consumption in modern marine engines as compared with that of former days.

We must now return to the consideration of the modern triple expansion engines, with a view for the information of non-professional people to giving a short description of the way in which the horse-power in every one of a set of these engines is equalised. As the steam pressure becomes continually less by passing through the cylinders and expanding into larger spaces, it is necessary to make up for this decrease of pressure by increasing the areas on which the lower pressure acts. This is the reason why the intermediate cylinder is of larger diameter than the high pressure one, and the low pressure than the intermediate cylinder.

The division of the gross power to be developed by a set of triple expansion engines into three nearly equal parts, one part to be the work done in each cylinder depends upon a principle which can be easily explained and understood even by amateur engineers; and it would be well in doing this to define a few technical terms. In all cases when the term pressure is used it means the steam pressure in lbs. on every square inch of surface.

Boiler pressure.	Pressure in boilers.
Initial do.	Pressure in a cylinder at the commencement of the stroke of piston.
Terminal pressure ...	Pressure in cylinder at termination of the stroke of piston.
Mean pressure	The mean of the varying pressures acting on the piston throughout its stroke.

Stroke of piston...	...	Distance travelled by it from one end of cylinder to the other.
Let M. P.	...	Be mean pressure.
And A.	...	Area (Cylinder diameter $^2 \times .7854$.)

Then in all the cylinders of a set of triple expansion engines M. P. $\times$ A. should be as nearly as possible equal (*vide* diagrams on page 113): that is, if the mean pressure throughout the stroke of piston multiplied by the area on which the pressure acts be nearly the same in every cylinder the three engines will be pretty equally balanced.

It is found in practice that the balance is not the same at all rates of speed, in consequence of the variations of the mean pressures. For instance, suppose the engines were being worked dead slow, the mean pressure in the largest, the low pressure cylinder would be *nil;* it would be doing no work, but would be pulled round by the other two engines. It is the custom of engine makers to aim at the engines being as well balanced as possible when working at full power. At lower rates of speed, down to a certain limit, the balance can be preserved by manipulating the link motions connected with the slide valves of the engines, which should, in all cases, be fitted with arrangements whereby the travel of the slide valves might each separately be shortened, if required, to equalise the power developed in the three cylinders.

Now it is evident that the fitting of the surface condensers, and the adoption of the triple expansion type of engines, have, by economising coal, nearly doubled the duration of our ships' efficiency at sea with the coal stowage; and if we left off here it would appear that

our Navy has benefited in every way by the change. But, alas! modern machinery, like every other good thing in this world, has not a few very serious drawbacks, some of which it will be necessary to notice here.

First, it has necessitated the use of very high pressure steam, as compared with that used thirty years ago, when the highest to which boilers were subjected was 25 lbs. on the square inch, sometimes as low as 15 lbs., and when boilers were old and worn as low as 10 lbs. and even 6 lbs. Now the boiler pressure used is 140 lbs., 150 lbs., and in many cases 160 lbs. on the square inch. It may be briefly remarked here that this great increase of steam pressure made it necessary to make boilers heavy and strong enough to safely stand the enormously increased strain due to these high pressures. But there was difficulty in finding space enough in our ships for large boilers, and also in providing for the additional weight to be carried, and therefore it was determined to have recourse to a forced draught, by means of which it was hoped that small boilers might be made to do the work of large ones. The system appears to have been rather hastily adopted on insufficient trial, and dozens of sets of boilers were designed and made on the assumption that what is now known to be an excessive forced draught, was bound to be in every way successful. Hence, in these days, we have dozens of sets of boilers in our ships which cannot safely do all the work they were designed to do, and these may be considered as the outcome of the boiler work of the past fifteen years. It proves the truth of what has

been already said, the absolute folly of adopting any invention, scheme, or system that has not been sufficiently tested by *actual experiment*, which alone can prove whether its adoption would be for the benefit of the Naval Service. The officials representing the purely naval element, the *sea-going naval element* on the trials of new inventions, should most jealously and minutely watch these trials, and especially with a view to ascertaining whether the new invention will add to the *continuous* efficiency of the Navy; the kind of efficiency that will be good for days, weeks, months, and even years; and not that spurious kind that will just enable he new thing to scrape through a *four hours'* trial.

It has been said that there should be a considerable difference "between the highest actual working strain and the breaking down strain," in order to ensure safety and continuous efficiency. How very small this difference is in many cases might be proved by taking one very modern case, and that the most recent, and, it may be added, the most successful in many respects of our modern ships of war, built in our own dockyards, the *Royal Sovereign*. The forced draught trial of this ship has been dealt with and fully remarked on in the preceding chapter, but in illustration of the single point now being discussed, it may be repeated, that on the trial all went well for three hours, but during the fourth and last hour the boilers began to leak, and this affected the development of engine power so much that that last hour was struck out, and the averages of the trial calculated from the performances of the first three hours. Now, if the Press reports of this trial

were correct, these boilers must have been perilously close to breaking down during the whole of the trial; and this being so, where, it may be asked, was the *considerable* difference" between the highest actual working strain and the breaking down strain," which, it is contended, is absolutely necessary to ensure the continuous efficiency of the machinery? I say this difference is necessary, and I presume it will not be disputed by any competent engineer. It is because of ample provision being made for this that the most stupendous works of civil engineering have remained unharmed for ages, and will probably remain so for very many ages more. It is because of there *not* being sufficient provision made for this that we hear, happily at rare intervals, of the collapse of bridges and other great disasters. And is it not of the greatest importance that the British Navy should be safeguarded by progressing on absolutely safe lines? So far as the machinery of our ships is concerned this can only be done by fixing the highest limit of working strain *well within* the breaking down strain.

That is all that is required. More than this is not wanted, and less than this will not suffice.

Now all these drawbacks as regards boilers have been caused by the adoption of the triple expansion type of engines and the endeavour to make small boilers supply a sufficient quantity of steam at the necessary high pressure to drive the engines to the utmost advantage. And it will be admitted that these drawbacks are very serious.

But this is not all; there are also others in connection with the engines which deserve to be considered.

Let us suppose, in illustration, the case of a large cruiser, which with twin screw triple expansion engines, and boilers worked with a safe forced draught, develops an engine power of 12,000 horses, and attains a speed of 21 knots. At this speed, and with the development of this power, the engines are, we will suppose, fairly well balanced, each of the three engines developing nearly the same power, and therefore causing an equality of strain along the crank shaft. Now, when the power is reduced, this balance is lost; and though it can, to some extent, be retained by a judicious use of the link motions, yet a limit will be soon reached when this can be no longer done. Also, with a further reduction of power there will soon be a point reached when the balance will be so entirely lost as to cause the low pressure engine to do nothing; and beyond this point this engine will not only do nothing, but will actually be dragged round by the other two engines. This is another of the drawbacks connected with the adoption of the triple expansion type of engines. It may be remarked here that in the case of a ship of the *Edgar* class, a first-class cruiser having a maximum speed, in round numbers, of 21 knots per hour, the variations of the indicated horse-power at lower rates of speed is very remarkable. In the statement annexed the I.H.-P. is shown opposite the rates of speed obtained by the development of the various degrees of engine power. These were the results of actual trials as reported in the Press.*

* Experimental trial of H.M.S. *Edgar*, first-class cruiser, 7,350 tons, 12,000 horse-power.

SPEED OF SHIPS IN KNOTS.	GROSS INDICATED HORSE-POWER.
20·97	12,550
18·83	8,524
16·50	5,206
14·00	3,023
13·40	2,511
11·87	1,756
9·60	890

Presumably the above trials were made under favourable circumstances, and under similar conditions the results when fleet cruising would be the same. Now, in the case of Her Majesty's ships, their passage speed, and what may be called their fleet evolution speed, is, generally speaking, between 7 and 12 knots; and, as we have seen in the case of the first-class cruiser, a ship that with an engine power of 12,000 horses will go 21 knots (maximum power and speed) will go 12 knots with under 2,000 and 7 knots with under 1,000 horse-power, it follows, that when working at ordinary speeds, *i.e.*, from 7 to 12 knots, the low pressure engine would either be doing nothing or be actually pulled round by the other two engines, causing a waste of engine power and a diminution of the coal endurance. This drawback will not be felt by ocean mail and other steamers, which, having to make rapid passages, always work at full speed, and thus receive the full benefit from the triple expansion type of engines. But this is not the case with Her Majesty's ships, and the question arises: Can any remedy be applied to prevent the waste of power and loss of coal? The reply to this would probably be "Yes, the engine doing nothing, or actually retarding the others, should, if possible, be cut off temporarily, and leave the other two engines to do the work alone,

which they would be well able to do." This seems plausible, but further consideration seems to point out a better way of effecting this. For the disconnection of the low pressure engine is made difficult because it is generally the after engine, nearest the propeller shaft, and at the after end of the crank shaft; also because of this engine being necessarily the only one in connection with the surface condenser. The disconnection of the high pressure engine, which is almost always connected with the foremost end of the crank shaft, would be much easier and more simple, and, if desirable, might easily and quickly be uncoupled from that end of the shaft, leaving the other part with its two cranks to revolve in its bearings as before. There are other reasons why it would be better to cut off the high pressure engine than the low.

1st. It would be easy to fit a very strong valve and box in the steam pipe jointed on the high pressure engine, so as to shut the communication between the boilers and that cylinder; the boiler steam pipe in that case being carried to and jointed on the intermediate cylinder, which would become the high pressure engine of a pair of compound engines.

2nd. The disconnection of the smallest (the high pressure) engine would not so seriously affect the maximum horse-power, developed with two cylinders, as would the cutting off of the large (low pressure) engine; for the steam pressure in the first case would act on the two larger areas of the intermediate and low pressure en-

gines, and thus ensure the greatest development of power.

3rd. As the steam pressure would act on the areas of the two larger cylinders, the boiler pressure when working at and under 12 knots might be reduced to the point that would cause the two engines to work at such a velocity as to give the ship the required speed, and this would conduce to the preservation of the boilers, the strain on which would be lessened in proportion to the extent to which the reduction of pressure would be carried. This alone would be of very great advantage in preserving the efficiency of the boilers.

4th. As has been already mentioned, the connections between the low pressure cylinder and the condenser are already made, and the making of new connections between the condenser and the intermediate cylinder, which would be necessary, would be much more difficult and expensive than the simple cutting off the steam from the high pressure cylinder, which is the only thing that would have to be done in disconnecting the high pressure from the other two cylinders.

Thus, if it be desirable, for the reasons stated, to work the machinery temporarily as a pair of compound engines, it seems to be every way preferable to disconnect the high pressure engine rather than the low. The reasons for this are considered urgent ones, and there is little doubt that if some simple arrangement could be fitted whereby the high pressure engine could be tem-

porarily disconnected from the other two it would reduce friction and prevent the performance of unnecessary work and the consequent waste of coal.

It may be remarked here that, if it be considered undesirable for any reasons to disconnect the end of the crank shaft in connection with the high pressure engine, an easy way of disconnecting the connecting rod might be fitted, and the whole of the crank shaft be allowed to run in its bearings as usual. This would be desirable, because it would keep the whole of the crank shaft running in the same line by preventing more wear on one part of the shaft than on another.

As has been remarked, triple expansion engines are of the greatest use in mail steamers, our ocean greyhounds, which are always working at full speed, and therefore to the utmost advantage. But in our ships of war, with an average passage or evolution speed of about 12 knots, there is little doubt there would be considerable advantage in working the engines as pairs of compound engines, made up of the intermediate and low pressure engines of the present triple type. It is considered in this connection that it should be easy for our engine makers to make and fit such arrangements as would make the disconnections and reconnections of the high pressure engine a work that would occupy only a few minutes; and this itself is a great reason why it should be done. Of course if the necessary disconnections, &c., occupied a day, or even half a day, it would perhaps be well not to make the change; but if, as stated, it could be done in a few minutes, it would be advantageous, for it would prevent a wasteful expendi-

ture of power, and so improve the coal endurance of the ship.

As to the way in which this change would affect speed: On a pinch a 21 knot ship could easily get 16 knots with the suggested compound arrangement, and that is all that would be wanted for ordinary fleet service. Of course in a time of war it would be better to work with all three cylinders, so as to be able to put on full speed at the shortest notice. But when at peace there is no doubt that the present triple expansion engines, converted into pairs of compound engines as suggested, would give all the engine power that could possibly be required for fleet service, and would cause a considerable saving of coal, which, in these days, is a matter of the very greatest importance, affecting, as it does, the duration of the efficiency of ships of war at sea. The foregoing suggestions are commended to the consideration of engineering firms who contract to make engines for the Navy. It is considered that it should not be difficult to fit an easy means of disconnecting the high pressure engine in each set of triple expansion engines, so that when not required for ordinary fleet service the other two engines might be worked as compound engines.

As to this last proposition, some may think that even temporarily converting triple expansion engines into the compound type would be retrogressing, taking a step backward; but this is not so, for when the principle of expansion of the steam would be carried out to the fullest extent in the suggested compound engines, no benefit, but positive injury, would be caused by

adding another cylinder. On the other hand, the power of connecting a third cylinder when required to work at full or any high rate of engine power is most beneficial and valuable, for reasons already set forth in the foregoing remarks. It may be admitted at once that the chief benefit which would be derived from the disconnection of a useless cylinder would be the prevention of the waste of engine power, *i.e.*, of coal, a matter of primary importance as regards modern war-ships, for they are wholly dependent for their efficiency on the steam machinery, which cannot be worked without coal.

There appears to be much scope for the exercise of the ingenuity of engineers in making such improvements in the present machinery as would improve the coal endurance of our sea-going fleets.

PART III.

NAVAL ENGINEERING IN WAR-SHIPS.

PART III.

CHAPTER I.

NAVAL ENGINEERING IN WAR-SHIPS.

Enquiry as to whether there is a correct idea generally of naval engineering science—Reference to opinions on the subject—Definition of the duties of engineer officers—Value of a well-ordered steam department as contributing to the successful service of every war-ship—Abilities and duties of engineer officers and engine-drivers compared and differentiated—Description in detail of the complexity of modern steam machinery—Requiring a thorough and general knowledge by engineers, compared with the knowledge of one special branch of it by engine-drivers—Why should it be necessary to have highly-trained engineer officers in our Navy?—Reasons given—No change should be made in the direction of lowering the standard of qualifications now considered necessary for the efficiency and safety of our ships—Remarks on the ability, care, and intelligent attention which must be exercised to produce and maintain the highest efficiency of naval steam machinery—Efficiency depends on two things—Condition and Treatment—Illustrations given of the serious effect produced by one part only respectively in engines and boilers not being in good condition—Examples of good and judicious, also of careless and bad treatment of machinery when working, with the effect in both cases—Illustrations of good and bad engineering in two exactly similar ships, doing the same work under the same conditions—Showing the effect on the maximum speed, and engine power; on the coal endurance, and the general efficiency of single ships and sea-going fleets and squadrons.—Conclusion.

MANY naval men and others appear to have a very hazy idea of engineering science, and especially of naval engineering. The large majority may be said to know very little about it, and it is this want

of knowledge that makes it difficult—indeed, almost impossible—to appraise at their proper value naval engineer officers and their services to the State. This can only be done by considering what they do, and their heavy responsibilities in the charge of the costly machinery now fitted in modern war-ships. This charge has been somewhat baldly described as "driving the engines to their utmost advantage and keeping the machinery in effective repair." (*Vide* "War Training of the Navy," by Captain Gerald Noel, R.N., *United Service Magazine*, July, 1891.) This definition of the duties of these officers does not convey to unprofessional people any clear idea of the extent and variety of the qualifications of a competent engineer, and the many calls upon his knowledge, capabilities, and resource in times of difficulty. All naval officers of experience are aware of the great value, as contributing to the success of a ship, of a well-ordered steam department, and yet there is much invidious disparagement of the officers who control and work these departments, judging from the opinions expressed and recorded from time to time, such as those which appeared in a letter in the *St. James's Gazette* a few months ago, and which seem to show an invincible prejudice against both the science of engineering and its professors.

Now what can have caused this? Two reasons may be given as probably the principal causes:—

1. A simple want of knowledge of naval engineering science; and, following from this,

2. A prevalent opinion that naval engineer officers are engine-drivers and nothing more.

As to 1. By this knowledge is not, of course, meant that which is acquired by the experience of a large fraction of a professional lifetime, but that which may be described as a knowledge of elementary scientific principles, and more especially a knowledge of those principles on which are based the design and construction of modern steam and other machinery. This knowledge would enable its possessor to understand the difficulties which have at times to be surmounted in the steam department, to accurately gauge the difference between the efficient and inefficient officer, and to estimate at its true value the importance of the officer, who, by his professional ability and close attention to the administration of his department, keeps the machinery in the highest state of efficiency.

As to 2. That naval engineer officers are engine-drivers and nothing more. This is a statement boldly made in the letter to the *St. James's Gazette*, already referred to. The writer does not sign his name, but states that he has high Service connections, a circumstance that no doubt has caused the letter to receive more attention than it would have received on its own merits, for the writer's own remarks and opinions are so extraordinary, and show such ignorance of the subject dealt with, that they do not seem to call for any comment; but as, on the point in question, he doubtless echoes the opinions of his Service relatives, and as many others may hold the same views, it will perhaps be useful to

argue the question whether naval engineers are engine-drivers and nothing more.

An engine-driver is to an engineer what the skilled labourer working a machine is to the designer and maker of the machine. "Then why," it may be asked, "do we not do away with engineer officers, and have only engine-drivers in the Navy; for the designing and making of the machinery are done before the ship goes to sea, and thereafter the engines have only to be driven?" There are several answers to this question. For instance, engine-drivers need not necessarily have a knowledge of the principles on which the machinery is designed, but it *is* necessary for some on board to have this knowledge, for reasons which will presently be given. Hence the necessity for competent engineer officers.

On board our larger ships of war there are scores of sets of steam engines, each set complete in itself. Now, though the underlying principle which governs these separate sets of engines is the same, there is an endless variety in the application of this principle. Hence one set of engines is often unlike any of the others, and it requires a thorough knowledge of the application of the principle, in the case of every set, in order to be able to at once detect and make good any defect that may arise. Now, any labourer or stoker with a little instruction can *drive* these engines, but, of course, these drivers do not know where to look for defects nor how to make them good.

The engineer possesses this knowledge.

Again, of these scores of sets of steam engines, including the propelling engines, in every large ship of

war, and, of course, the smaller number in smaller ships, all, when once started, are *automatic* in their action. They will continue to work faster or slower as more or less steam is used, without effort or alteration on the part of the engine-driver, except as regards lubrication and attention to the working parts. But in order to preserve this automatic action, without which efficiency would be impaired or altogether lost, it is obvious that the adjustments of the various parts which govern this action must be carefully made and continuously preserved. An engine-driver need not know, and, generally speaking, does not know, how to make and preserve these adjustments, absolutely necessary for the efficient working of the engines.

The engineer possesses this knowledge.

Our war-ships have sometimes to be away from England for weeks, months, and years, while serving commissions on some distant foreign stations, and the ship's staff have to maintain the efficiency of the machinery. Could we reasonably expect this to be done with none but engine-drivers on board? Some years ago a vessel left England for a four years' commission on the Australian station. On the way out a small steel rod broke, and, there being no material of the exact kind on board a new rod was made at the Cape of Good Hope Dockyard. The cost was £5. After serving the commission the vessel arrived in England with the machinery in better order than when she left four years before. As already stated, the total cost of repairs at a dockyard during the four years was £5, the efficiency being otherwise maintained by the ship's staff. But this could not

have been done had there been none but engine-drivers on board.

Engine-drivers are generally specialists. They are engine fitters, turners, boiler makers, coppersmiths, and sometimes men of the stoker class. But an engineer understands all these trades; he knows, or should know, how to do all this work, and how it should be done. Before becoming qualified engineers they have to pass examinations as to their ability to do this work, and produce specimens of workmanship. They are also required to possess very high theoretical knowledge of the science of engineering, which, in the opinion of competent judges, is of the greatest advantage to them and to the Navy in which they serve. Some few may contend that this high theoretical training is not necessary, but even these will admit that the combination of theory and practice in due proportion makes good and useful engineers, and that, in any case, the possession of high theoretical knowledge causes a great difference in all-round ability between the engineer and the mere engine-driver.

The idea that these are two names for the same thing is probably more or less prevalent among many executive and other naval officers, and therefore the point has been argued in the foregoing remarks. There can be little doubt that the formation and expression of so erroneous an opinion must be ascribed to a simple ignorance of engineering science, and it is hoped that the argument on the point will induce many to modify their views on this subject.

It may be asked, "Why should it be necessary to

have highly-trained engineer officers in our war-ships?" The answer is, Because they *are war-ships.* Merchant steamships run from port to port at a high rate of speed, with no special regard to economy in coal consumption; and at the end of each trip they lay up for examination and necessary repairs. This is done in a time of peace, but in a time of war there is little doubt that all, except a few specially built vessels of exceptionally high power and speed, would have to lay up in port or run the risk of being captured. But this is reversed in our ships of war, which in war time are required to be most efficient. Each ship must be regarded as complete in itself, self-supporting, self-sustaining, depending on nothing extraneous for the preservation of its highest efficiency. Is it not obvious, therefore, that for the attainment of this great end we should use the very best means at our disposal, and that with a view to the continuous efficiency of our costly Navy, there should be in every ship highly-trained engineer officers, who would thoroughly understand, in all its innumerable details, the whole of the machinery of which our ships are now full, and some of which is of an extremely delicate and complicated character? Would it be wise to put the fate of our war-ships and the interests of the Navy in the hands of less competent men?

To sum up this part of our subject: It is submitted that the foregoing remarks prove that for no reason whatever should there be any alteration in the entering and training of our engineer officers in the direction of lowering the standard of qualification. It may be hoped

that those who administer the Navy will resist any proposal to make any change in this direction, for if it were made our future engineer officers would approximate to the engine-driving class. Let Admirals and Captains ask themselves, in view of taking our fleets and ships to sea in war time, whether it would be pleasing to them to know that the steam departments, so vital to the continuous efficiency and even safety of the ships, were being controlled and managed by an inferior class of men.

It would be well, perhaps, to make a few remarks as to the engineer officers, and the ability, care, and intelligent attention they exercise in the performance of their duties in charge of the machinery of the ships in which they serve. In doing this their previous scientific training will not be considered, except in so far as it conduces to their success in the management of their departments, for this training is not useful unless it conduces to this end.

A good officer will devote his attention principally to two things :—

1. The *condition* of the machinery and boilers.

2. The *treatment* when machinery is being worked.

On these two depend the efficiency of the steam department of every ship.

1. As to condition: It includes much that need not be mentioned here; but a few points might be remarked on to show the importance of condition as affecting efficiency. Boilers should be kept clean both on the water and the fire side of the plates and tubes constituting the heating surface, but especially on the *water* side,

because the formation of scale prevents the free transmission of heat through the plates to the water, and because when once the scale is deposited on the tubes and tube-plates it is impossible to remove the greater part of it without drawing the tubes, and replacing them when cleaned, or putting in new tubes, involving much expense, and the delay of the ship while the work is being done. But in many cases, unless the scale is very thick, the ship is not laid up for the removal and cleaning of the tubes, but continues running, with the result that there is a very great waste of coal, and, what is of even greater importance, a considerable loss of efficiency as regards the development of the maximum horse-power of the engines and the attainment of the highest rate of speed of the ship. In all cases in our war-ships, with barely boiler power enough for the requirements, it is simply impossible to get the maximum power with the boilers in bad condition as regards cleanliness. Thus, in this one matter of cleanliness—and several other points could be mentioned affecting condition—it will be seen how much the condition of boilers affects efficiency. In attending to this the good officer will have constantly in view getting the most out of the coal burned for the general service of the ship. Every ton of coal wasted by the boilers not being in good condition is so much taken off the coal endurance,* and therefore diminishes the *duration* of the efficiency of the ship.

The condition of the engines also affects economy and efficiency. We will suppose one part is not in

* See "Coal Endurance," Part 4, Chap. I.

good order. A leaky piston working in a low pressure cylinder causes steam to pass into the condenser without doing its work in the cylinder. Now the coal burned to generate the steam that so passes into the condenser is wasted *so far as that cylinder is concerned.* So much for economy. With the low pressure piston in this condition the efficiency of the engines would be impaired at all rates of speed, and if the leakage were serious it would be impossible to work the machinery at the highest rate and develop the maximum power. Many other parts of the engines might be mentioned, but this will suffice to show how seriously efficiency might be impaired by only this one part not being in good condition. A good engineer officer will therefore pay continually the closest attention to the *condition* of the machinery and boilers.

2. As to treatment when engines are being worked.

An *engine-driver,* when the steam was raised, would let the steam into the cylinders and start the engines. He would open the regulating valve till the machinery was working at the required speed, and thereafter content himself with attending to lubrication. Not so the engineer. He would work the engines on a definite plan. For example, he would probably arrange the link motions—it can easily be done in most cases when engines are working—so as to get the utmost benefit from the expansion of the steam, and also to cause, as far as possible, an equal distribution and development of power in all the cylinders ; he would, by a judicious use of the steam-jackets, prevent loss by liquefaction of the steam, and too great a variation of temperature in

the cylinders, and would do this so that the steam would retain its usefulness as a lubricant. All this and much more he would do, which would conduce to economy and increase the efficiency of the propelling engines and of the boilers.

In illustration of the foregoing, a circumstance may be mentioned which occurred some years ago, during the six weeks summer cruise of the First Reserve Squadron, consisting of eight or nine ships. As a rule, the squadron while cruising steamed in two lines, did the same work, and travelled over the same ground. Every morning at eight a signal was made from the flagship, directing each ship to report the quantity of coal burned during the preceding twenty-four hours. There were three or four ships of about the same class, build, rig, tonnage, and horse-power; and it might be thought, as the work done by these ships was the same, that the consumption of coal would be also about the same; but really the variation was very remarkable. One ship, for instance, would report 20 tons; another from 27 to 30 tons; and this was not for one day or a week, but continued the whole cruise, and for two successive years. Now there must have been some reason for this. Perhaps some of it was due to circumstances over which there was no control by those in the ships, such as the quality of the coal, &c.; but it may reasonably be concluded that very much of it was due to the *condition* and *treatment* of the machinery, and to the care, attention, and ability exercised by the respective engineer officers.

By way of showing how much the efficiency of a war-

ship depends on the action of the engineer in charge, it would be well to suppose a case. This might be done as follows :—

There are two large cruisers in a home port in commission waiting orders. These vessels are of the same class, tonnage, and engine-power, built and engined by the same firms, and having been in commission for more than a year, the condition of the machinery and boilers is that due to the attention and ability of the engineer officers in charge. Of these one is a very zealous and able officer, the other is neither able nor zealous. The result is that the machinery of one vessel is in very good condition, and receives the most careful and judicious treatment when at work. In the other the machinery is not in good condition, and the treatment when at work is not what it should be. The consequence will be that one vessel will burn more coal than the other in obtaining a given distance at the same speed and under the same circumstances as to draught of water, state of ship's bottom, force and direction of wind, and state of the sea. Say this difference amounts to 20 per cent., which is by no means an extreme assumption, for it will be remembered that, in the cases which have been mentioned on the preceding page, the coal consumption in two similar ships doing the same work, was as 20 to 27, a difference of 35 per cent. Therefore the difference of 20 per cent. in the coal consumption of the two ships is a moderate assumption. How would this work out ? The two cruisers receive orders to steam a distance of 4,500 knots, at a speed of 12½ knots, which will give 300 knots a day. One vessel

burns 50 tons of coal a day; the other 60 tons, or 20 per cent. more. The coal stowage in both cases is 900 tons. In fifteen days both vessels arrive in port, the one, burning 60 tons a day, having burned the whole of the 900 tons; the other, burning 50 tons per diem, having burned only 750 tons. She has, therefore, 150 tons left, with which she could steam at the same speed three more days, and obtain a further distance of 900 knots. Thus there is a difference in the coal endurance of the two ships, of three days steaming at a $12\frac{1}{2}$ knot speed, and a much greater number of days at lower rates of speed. Another way of showing this would be that of these two ships working with a fleet at slow cruising speed, one could keep the sea from ten to fifteen days longer than the other with their coal stowage of 900 tons; and this great result, which would be of immense importance in war time, would be entirely brought about by the care, zeal, attention, and ability exercised by one, as compared with the other, of the two engineer officers in charge of the machinery of the ships.

Does not this prove that in our ships of war it is essential that we should have the highest engineering talent we can get, and how fatal to efficiency it would be to have the engine-power controlled and managed by an inferior class of men? Nothing but the experience gained in a great war will really and practically test these and similar questions. Meanwhile, during peace, which is, as far as the Services are concerned, simply a time of preparation for war, it would be well to be careful that in the training of both execu-

tive and civil officers nothing shall be done in the direction of lowering the high standard of qualification now rightly considered necessary. This applies with special force to the steam branch of the Navy, whose members are the professors and students of naval engineering science, the value and importance of which will, it is hoped, be more generally and highly appreciated as time goes on, and as the vast responsibilities of our modern steam Navy are realised.

CHAPTER II.

NAVAL ENGINEERING IN WAR-SHIPS.

Good engineering in fleets and squadrons—How does it affect coal endurance?—Economy in coal consumption intimately and inseparably connected with efficiency—Economy a measure of efficiency—Of boilers—Also engines—Illustrated by the performance of two similar ships as regards build, rig, class, tonnage, and engine-power—How bad engineering would effect the efficiency of a war-ship when manœuvring before the enemy—Rewards should be given to officers who by good engineering improve the coal endurance of their ships—Enquiry as to whether it is possible for the staff of the engineer department in every ship, during a commission, to keep the engines, boilers, and machinery generally, in an efficient condition without assistance from dockyards, except by supplies of material—Engineer officers and dockyard officials will probably disapprove of the proposition—Objections met by considering the circumstances under which all ships are commissioned and the service performed during commission—Conditions imperatively necessary for the carrying out of this great work—Time and opportunity for making examinations and timely repairs, and the provision of an efficient engine-room staff—Incidental reference to the reduction of the number, and the lowering of the quality, of the mechanic staff of the ships lately ordered to be carried into effect by the Admiralty—Author's experience for nearly forty years—Always supported and assisted by Captains in maintaining the efficiency of the machinery by the ship's staff—Limits to this proposition considered—Heavy breakages must be made good by dockyards—But such breakages can be, generally speaking, prevented by careful management—Instances of occasions on which machinery defects lists have been sent in when quite unnecessary—Chiefly in accordance with a bad old custom—This should be discouraged for many reasons—Appeal to officers to keep their ships efficient by the fleet officers and men—Can the fleet mechanic ratings be improved and made more fit to carry out this great work?—Definite plan proposed—Using the Steam Reserves as a means of improving the mechanical ability of the fleet men—The necessary appliances in the Reserves—Large workshops—All kinds of machines

worked by steam-engines — Smitheries — Foundries — Opinion of dockyard officials adverse to the extension of Steam Reserve work considered—Reasons for discounting the value of their opinions—Efficiency of our fleets of paramount importance—Dockyards only useful in so far as they promote this efficiency, which will be increased by making the fleet mechanics more competent to make all ships in commission self-supporting—Operation of the plans proposed—Results as to the younger and less experienced men, making them more fit to perform their duties when drafted to ships in commission —As to the older men, benefiting them by giving them practice in doing the better kind of repairing work—Conclusion.

IN the preceding chapter I endeavoured to show the value of good engineering as affecting the efficiency of sea-going fleets and squadrons, and especially the duration of that efficiency as shown by the coal endurance of similar ships. I showed there that economy in the consumption of coal is always intimately and inseparably connected with efficiency; indeed it may well be said that economy is a measure of efficiency. It will, perhaps, be useful to make a few remarks on this branch of our subject before going on to other matters.

First, then, it has been said that economy is a measure of efficiency. For take boilers: It will not be disputed that they are most efficient when capable of generating the greatest amount of steam with a given quantity of coal; in other words, when the greatest possible amount of work can be got out of the boilers, then they are most efficient, and in the best condition as to cleanliness, freedom from leakage, and in all other respects. Similarly as to the engines: any defects which cause a waste of steam, *i.e.*, of coal (and many, if not most, defects cause this waste), will, of course, result in lessening the amount of work done with a given quantity of

coal. Thus in two similar ships* as regards class, tonnage, and engine-power, built and engined by the same firm, if they steam together while making a passage, at a speed which will give 300 knots a day, with a daily coal consumption of 50 tons in one case and 60 tons in the other, and the steaming is done under the same circumstances as to draught of water and resistances generally, then it may be safely said that the economical ship is the more efficient ship. This is true at all rates of speed and development of engine-power, but it is more especially the case at the highest rate of speed, and when working at the maximum horse-power. Any falling off in this respect is most serious, and affects the efficiency of a ship vitally, preventing, as it would, that rapidity of manœuvring so essential when before the enemy. In the case of the two vessels referred to, the efficient ship will attain its greatest speed and develop the maximum engine-power with a certain consumption of coal; but the inefficient ship, with the same consumption of coal, will not attain the same speed or develop the same power, and the difference in the performances of the two ships in these respects will be in proportion to the number and seriousness of existing defects, and want of good management when working the machinery of the inefficient ship. Thus economy measures efficiency: the economical ship is the efficient ship, and, conversely, an efficient ship will always be an economical ship. And this directly affects a most important matter, viz., the coal endurance, *i.e.*, the time a war-ship can keep the sea with her

* See "Naval Engineering," Chap. I., p. 143.

coal stowage.* As to this, it may be said that any officer who, by good engineering, can succeed in increasing the *duration* of the efficiency of his ship, *i.e.*, of improving the coal endurance, as compared with similar ships, deserves well of his superiors, and, in very special cases, should receive reward by promotion or otherwise. It would show on the part of the Admiralty an appreciation of thoroughly good naval engineering as shown by results, and promote a spirit of emulation among naval engineer officers which could not fail to have a beneficial effect on the service generally. More will probably be said on this subject by-and-bye.

There is another matter of the greatest importance connected with naval engineering which well deserves consideration, viz., the possibility of the staff of the engineer department in every ship keeping the engines, boilers, and machinery generally, *during a commission*, in an efficient condition without assistance from the dockyards, except with respect to the supply of material for repairs. Now, at first sight, this may be unpalatable to many engineer officers, who perhaps consider that they already have sufficient to do to keep their departments going, even with occasional assistance from the dockyards. Also, there may be many dockyard officials who would disapprove of this proposition, partly because they think the work would not be so well done, but mostly, perhaps, because to some extent it would appear to derogate from the dignity and im-

* See on this subject, Part 4, Chap. I., "The Coal Endurance of Her Majesty's Ships."

portance of the dockyards as repairing establishments, without assistance from which ships in commission cannot be kept going.

As to engineer officers: I do not see why, with time and opportunity given for examination and necessary repairs, the engine-room staff in every ship should not keep everything in connection with their department in a state of efficiency during a commission without assistance from dockyards. For let us consider the circumstances under which all vessels are commissioned: First, as to the ships; second, as to the staff of men sent on board on commissioning.

First, as to the ships. Take a new ship: The machinery and boilers are designed and made according to specifications, and under strict supervision, so as to work at the highest power, and to bear the strain due to that power, with such a considerable margin of strength as to make it impossible, with skilful management, to break down under this strain. It may be remarked here that new machinery does often break down under trial, and this, no doubt, is so; but this is due to one or more of three things, viz., to faulty design, to inferior material, or to bad workmanship. This does not affect my proposition, which is, that all steam machinery is designed with a view to its being impossible, with careful and judicious management, to break down under the greatest strain that can be brought on it when working at full power. Not only so, but there are several trials to test the ability of the machinery to bear the strain brought on it when at work. There are the contractors' preliminary and natural and forced draught

trials, which have to be made without any breakdown, in the presence and to the satisfaction of numerous Government officials, before the machinery is accepted. Then, when commissioned, there are the basin trial, and the preliminary and full-power trials under way. Therefore, before a new ship commences the work of her commission, the steam machinery has to undergo two complete series of trials, viz., the contractors' and the commissioning trials. Similarly, in the case of ships repaired and refitted by the dockyards for further sea service, there are the same series of trials, viz., the dockyard trials made by the dockyard officials, and witnessed by the fleet engineer officers; and the commissioning trials made by the fleet officers, and witnessed by the dockyard officials. All have to agree that these trials have been satisfactory, and to sign a declaration to that effect.

If vessels pass satisfactorily through these two series of trials, which include two full-power trials, it may be presumed that the steam machinery is in thoroughly good order at the commencement of every commission. Now, considering that the machinery of all vessels during the time they are in commission is, generally speaking, while performing ordinary service, worked at very much under the full-power—probably at less than half the maximum horse-power—it follows that, except at intervals, when running off for a few hours the periodical full-power trials, the machinery very seldom has to bear the full strain, which it has safely borne while making the trials before and immediately after commissioning. Therefore it should not be difficult

during a commission for the engine-room staff to keep the machinery in good order without outside assistance, provided that facilities be given for making necessary examinations and repairs, and that the engine-room staff be efficient.*

Second, as to the staff being efficient. When a ship is commissioned, very great care is taken to draft to her from the Steam Reserves, engine-room artificers and stoker mechanic ratings of every trade appertaining to engineering—engine fitters and turners, boiler makers, smiths, coppersmiths, tinsmiths, and in very large ships and flagships, moulders and other specialists—so that these men, under the direction of able engineer officers, are, or should be, fully competent to do any kind of work, either new or repairing. Here it should be mentioned that all large vessels, all vessels over a certain size, have workshops fitted on board with many machines of various kinds, driven in the largest ships by a steam-engine; these workshops with their appliances, being, in fact, small factories in which any kind of work can be done, excepting that exceeding a certain size and weight. Also, it should be noted that every ship on commissioning is supplied with a large quantity of carefully-selected material of every kind, to be used in case the engines and boilers require repair.

* There has recently been a readjustment of the engine-room complements of Her Majesty's ships. The number of engineer officers have been reduced from 20 to 50 per cent., and chief stokers (skilled labourers) have been substituted for about 30 per cent. of the engine-room artificers (qualified mechanics). This will seriously impair the efficiency of the engine-room staffs, and make it difficult to carry out the great work of maintaining the efficiency of the machinery during a commission by the fleet men.—See "Engine-room Complements," Part 4, Chap. II.

So that in all commissioned ships there are the men, the machinery, the tools, and the material necessary for the repair of all machinery made defective by fair wear and tear.

To sum up the conditions under which all ships are commissioned: The machinery is in excellent condition, having recently passed satisfactorily through the full-power and other trials; it will, during the commission, generally speaking, be worked much under the full power, and will therefore have to bear only the strain due to that moderate power; an efficient engine-room staff is drafted, and material of all kinds supplied; every appliance necessary for repairs is fitted; and lastly, engineer officers of great theoretical and practical ability are appointed. Considering all this, it is repeated, and it will well bear repetition, that it surely should be practicable during a commission for a ship's staff to keep the machinery in good order, without assistance from dockyards, assuming, of course, that time and opportunity be given to make necessary examinations and repairs: to put in "the stitch in time that saves nine."

As to time and opportunity for examination and necessary repairs: In the course of an experience of nearly forty years' service, I have always found it easy to arrange with the Captains of my ships for time and opportunity for repairs while the ship was in harbour, or at other times when cruising or making passages. I have heard of Captains being so unreasonable as to expect and order their engineer officers to have at all times, whether at sea or in harbour, the machinery

ready for service at two or three hours' notice. In such cases it would, of course, be quite impossible for the staff of any ship to keep the machinery efficient without outside assistance. No doubt there have been such Captains, who must have been very ignorant and arbitrary men, but I have never during my long career served under such. I may mention here that during that part of my service when I was in sole charge of the machinery of my vessels, which dates from the time I was twenty-three and a half years of age, I have always practised the doctrine I now preach to others, viz., that the efficiency of the machinery of a ship should be wholly maintained by its own staff. I do not dwell on this for obvious reasons, but I mention it because it seems to prove that it can be done, and because it should be stated that every support and assistance in doing this have been most readily and heartily given by the Captains under whom I have served, who have always been as much interested as myself in the vessels being self-supporting, maintaining efficiency without extraneous help. Of course it is recognised that there are limits to this proposition, as to all others. Defects due to heavy breakages—such as broken crank shafts—must, of course, be made good by dockyards. But this, by the way, touches the efficiency of a ship's staff; for assuming that the machinery at the time of commissioning stands a greater strain than it will be called upon to bear during the coming commission, it seems reasonable to say that, with *careful management*, no heavy breakages should occur. "Prevention is better than cure." The officer who, by careful manage-

ment, prevents a serious breakdown, and otherwise maintains efficiency, is a much more useful man for the naval service than the genius who makes a good repair of machinery which has broken down through neglect or carelessness.

Before proceeding to consider whether the engine-room artificer and stoker mechanic ratings could not be improved, and made more fit to carry out the work of maintaining the efficiency of the machinery during ships' commissions, it may be well to give some proof of a necessity for some change in this direction, and this might be done by a reference to what has happened, and is still happening, to ships newly commissioned. There have been many instances of such ships passing through all steam-machinery trials satisfactorily, and yet on proceeding from, say, Sheerness or Portsmouth to their stations, and calling at Plymouth *en route*, lists of defects have been sent in on arrival at the latter port, though the vessels have steamed down Channel at a moderate speed, and therefore the machinery has not been subjected to anything approaching so great a strain as that borne on the previous full-power trials. On the first page of the printed defect list form, the Captain and officer in charge of the department make and sign a declaration that the specified defects exist, and that they cannot be made good without assistance from the dockyard. It would almost seem that such defects develop, not because of the strain on the machinery by working the engines, but because of the ship being in the vicinity of a dockyard. In my early days I have sometimes known the

chief engineer to direct the senior to prepare a list of defects on approaching a port in which there was a dockyard. "But," the senior has sometimes remarked, "there are no defects of any kind which *we* cannot make good on board." "Never mind," replied the chief, "it is the *custom* to send in lists of defects on arrival in port, and we will keep to that good old custom; so prepare a list of some kind." Now this kind of thing should be sternly discouraged for many obvious reasons, the chief of them being that it promotes a spirit of helplessness in the fleet officers and men, who are, or should be, fully competent, with time given, to make good any ordinary defects that may arise. Our naval engineer officers are, for the most part, talented, zealous, and able professional men, fully equal to anything that may occur in the way of ordinary machinery defects due to fair wear and tear; and therefore it would appear that the continual sending in of lists of defects is caused, in some measure, by the carrying out of a bad old custom that has obtained from the earliest days, and not from any real necessity. It would be, indeed, a real triumph of naval engineering if, in some few ships, as a commencement, the engineers in charge, aided by willing staffs, succeeded in keeping their departments thoroughly efficient without assistance from dockyards, and such officers would deserve, and should receive, the highest reward possible.

We may now consider the question: Is there any means by which the engine-room artificer and stoker mechanic ratings could be improved, and, without a shilling's additional expense, made more fit to carry

out the important work of maintaining the efficiency of the machinery of the ships in which they serve during the commission, without assistance from dockyards? The answer is, Yes, it could be done by making more use than at present of the Steam Reserves, by employing the fleet mechanic ratings much more than they are in supplementing the work of the dockyards in the making good machinery defects. These fleet mechanic ratings during the intervals between the commissions served in ships are employed on the home station, chiefly in the Steam Reserves at Chatham, Portsmouth, and Plymouth. The total number of engine-room artificers and stokers employed in each Steam Reserve varies from 1,000 to 2,000 men. Of these, of course, only a fraction, but still a considerable fraction, are mechanic ratings. Now these men would be most usefully employed in the three ports in making good the defects of commissioned ships and likewise of small ships being refitted for commission. If they were so employed they would be doing very useful work for the Service, and, what is much more important, would be increasing their expertness and ability in doing the very same kind of work they would be required to do when drafted to commissioned ships, viz., making good machinery defects as they arise, and so keeping their ships efficient without outside assistance. No doubt some work of this kind is now done by the Steam Reserves, but it might be largely increased with advantage to the men and without much difficulty, for there are attached to every Steam Reserve very large workshops, in which are all kinds of machines worked

by steam-engines, and every appliance required for doing the work.

It is possible that the suggested extension of Steam Reserve work in making good machinery defects of ships, refitting or in commission, will not be viewed with much favour by dockyard officials, probably for two reasons: 1st, because they consider the work would not be as well done; 2nd, because it might be thought to derogate from the importance and dignity of dockyards as building and repairing establishments. I have heard engineer officials of dockyards express adverse opinions as to the Steam Reserves taking any considerable part in making good machinery defects of ships either refitting or in commission. They held that the dockyards should do this work, and that the fleet mechanic ratings in the Steam Reserves should be employed in the *care* and *preservation* of the machinery of ships in the Reserves, which are very seldom, if ever, under steam; perhaps once or twice a year, each time for only a few hours. Of course no defects can well arise from such steaming, and so, if this idea were fully carried out the fleet men would never have any of this important and very improving work to do. Most of these dockyard officials are, no doubt, able professional men, and served for a short time in the fleet as naval engineer officers; but some of them have been for so long a time in their present positions in the yards, and away from the fleet proper, that they have, to some extent, lost sympathy and touch with fleet work, concerning themselves chiefly with the administration of their departments. It may, indeed, be said

that they do not fully understand the requirements in detail of our fleets as *sea-going* ships of war. They probably are dockyard men first and fleet men afterwards. This naturally discounts the value of their opinions as to the training of the fleet mechanics for service afloat. Naval men hold that the efficiency of our fleets is of paramount importance, and that dockyards are only useful in so far as they promote this efficiency. And this efficiency will be promoted by making the fleet mechanics more competent to carry out the important duty of making all ships in commission self-supporting.

It is therefore considered reasonable that the fleet mechanics, *i.e.*, the engine-room artificer and stoker mechanic ratings, should, while serving in the Steam Reserves, be employed, to a much greater extent than at present, in making good machinery defects of ships. If this were done the Steam Reserves would be most efficient schools of instruction for the younger and less experienced men, making them more fit to perform their duties when drafted to commissioned ships, and it would benefit the older men by giving them experience in the better kind of repairing work. Finally, it would enable the Steam Reserves to draft a more able class of mechanical ratings to commissioned ships, and thus make it easier for the staff of every ship during a commission to maintain efficiency without assistance from dockyards.

This cannot be done unless a very earnest effort be made by all the members of the departmental staff. It would make it easier to do this if some method were

adopted which would ensure regularity of action and prompt attention to small defects before they grow into big ones. In the next chapter I propose to suggest a definite plan for effecting this, and also a simple and ready way of placing on record the performances of all ships while in commission, with a view to singling out those which are most successful in being self-supporting, and in order that the services of the most able officers may be recognised and rewarded.

CHAPTER III.

NAVAL ENGINEERING IN WAR-SHIPS.

The maintenance of the efficiency of the machinery of every war-ship during commission by the ship's staff, without assistance from dockyards, except as to the supply of material for repairs—Definite plan for effecting this, formulated—Possible difference of opinion on this subject—Engine-room complement of a modern war-ship taken in explanation of the plan—Principle on which the plan is based—Assignment of the various parts to members of the staff for special care and oversight—Tabular statements, showing: (1) the assignment of the parts; (2) the full engine-room complement—Adoption of the plan would not interfere with the good order and discipline of the department—Reasons given—Though special men are told off to care for certain parts, yet, in cases of emergency, all to be available for service in other parts—Example—What results may be expected by the adoption of the plan—(1) as regards the fleet; (2) as to the dockyards—First the more important—Possible views of engineer officers—Method of ascertaining the ability of some, as compared with others, with a view to rewarding the most deserving—Reference to the suppositious cases mentioned in Chapters I. and II., of two large cruisers of the same class, tonnage, and engine-power—Performances of these ships during a commission of three and a half years estimated—Deduction: economy in the consumption of coal a fair measure of efficiency as regards naval engineering—Results of the performances of the two ships during the commission obtained from the engine-room registers on paying off—Results tabulated—Should not this be done in the case of every ship on paying off?—Reasons—The subject illustrated by recording a page out of the Author's Service history—Thirty years ago the machinery was less complicated, and there was less of it, than at the present time, therefore easier to keep in good order—Set-off to this: thirty years ago there were no engine-room artificers or stoker mechanic ratings—Can the great work of maintaining the efficiency of ships while in commission be done by fleet men?—Should not it be attempted by (1) the adoption of the proposed or some similar plan; (2) the improved training of all fleet mechanic ratings as suggested in the last chapter—Remarks on this subject—The strengthening of the Steam Reserves necessary—

To what extent should this be done?—The most important element—The exhibition of thoroughly good naval engineering by the engineer officers absolutely necessary to ensure success.

AT the end of the second chapter on this subject it was proposed to formulate a method which, if adopted, would much facilitate the great and important work of maintaining the efficiency of the steam machinery of every war-ship during commission by the ship's staff, without assistance from dockyards, excepting the supply of material for necessary repairs. On this matter the opinions of many able engineer officers may differ; I therefore offer my views for consideration with those of others, premising that I have myself acted on these views with some success during my service in the Navy. An illustration of this will be given by-and-bye.

My plan is to assign to every engineer officer and chief, and other petty officers serving in a commissioned ship, certain parts which each one would specially care for and look after. We will take a case—a modern war-ship, with double screws, triple expansion engines, two boiler-rooms, each with its set of boilers and connections, and with all the auxiliary steam machinery now fitted. In this ship, when in commission, there would probably be:—

Fleet Engineer	1
Engineer	1
Assistant Engineers	3
Chief Engine-room Artificers	2
Engine-room Artificers	11
Stoker Mechanics	6

The fleet engineer would, of course, be in responsible charge of the whole department, and of all the

machinery, steam or other, in the ship. The assignment of special parts to every member of the whole staff would be as set forth in the annexed tabular statement—I—by which it will be seen that the senior engineer will have, under the direction of the fleet engineer, general supervision of all the work done by each assistant engineer and the staff serving under his orders. One assistant engineer has assigned to him the starboard engines and after boiler-room; another, the port engines and foremost boiler-room; and the third, all auxiliary machinery outside the engine and boiler-rooms; watertight doors, flooding and pumping arrangements, and pipe, valve, and other connections with hull and compartments. Each assistant engineer will have, to assist him, a trained staff of engine-room artificers, as shown in the diagram. It will be noticed that there are three engine-room artificers not appropriated for what may be called oversight work, and they have been purposely omitted, because they represent the fraction of all drafts to newly-commissioned ships which have not experience and ability enough to do the work. These are the comparatively newly-entered men, who, however, will be useful in doing general work, and who will quickly acquire the ability to do the superior work done by the older men.

TABULAR STATEMENT.—I.

Suggested assignment of parts of the Machinery of a War-ship, to be specially watched and cared for, as stated, by members of the Engine-room Staff.

FLEET ENGINEER.
In responsible charge of Machinery of every description.

SENIOR ENGINEER.
General supervision.

ASSISTANT ENGINEER.		ASSISTANT ENGINEER.		ASSISTANT ENGINEER.	
Supervision: Starboard Engine-room and After Boiler-room.		Supervision: Port Engine-room, and Foremost Boiler-room.		Supervision: Machinery, &c., outside Engine-rooms.	
CHIEF ENGINE-ROOM ARTIFICER.	ENGINE-ROOM ARTICIFER.	CHIEF ENGINE-ROOM ARTICIFER.	ENGINE-ROOM ARTICIFER.	TWO ENGINE-ROOM ARTIFICERS.	TWO ENGINE-ROOM ARTIFICERS.
Starboard Engines, Shafting, and Connections.	After Boiler-room, Boilers, and Connections.	Port Engines, Shafting and Connections.	Foremost Boiler-room, Boilers, and Connections.	Auxiliary Machinery outside Engine-rooms.	Watertight Doors, Pipe and Valve Connections, Hull and Compartments.
ENGINE-ROOM ARTIFICER.		ENGINE-ROOM ARTICIFER.			
Auxiliary Machinery in Starboard Engine-room, and to assist Chief Engine-room Artificer.		Auxiliary Machinery in Port Engine-room, and to assist the Chief Engine-room Articifer.			

TABULAR STATEMENT.—II.

ASSUMED COMPLEMENT.

Officers.		Petty Officers.	
Rank.	No.	Rating.	No.
Fleet Engineer	1	Chief Engine-room Artificers	2
Engineer	1	Engine-room Artificers	11
Assistant Engineers	3	Stoker Mechanics (probably)	6

NOTE 1.—All chief and engine-room artificers to be considered as available for watch-keeping under steam.

NOTE 2.—The three engine-room artificers, not appropriated, to be available for any general work as found necessary.

NOTE 3.—Stoker mechanic ratings, according to the number drafted to be assigned to positions as requisite.

Thus to the officers and fleet mechanics of this ship have been assigned certain parts of the machinery which would be carefully looked after, and it is considered that the adoption of this methodical system could not but result in the whole of the machinery being kept in much better order than by any other plan of what might be called a scrambling kind, for there would be much emulation and a very sharp competition between the members of the staff as to which set of engines, for example, would be kept more efficient than the other. The principle might be extended with advantage to the stoker class, many of whom are very intelligent men, who would speedily become interested in, and well acquainted with, the requirements of the minor parts which they were told off to specially care for.

The adoption of this plan would not interfere with good order and discipline, for in all cases the petty officers would be under the orders of the assistant engineers, who would report to the senior engineer, who in his turn would be in constant communication with the fleet engineer in charge of the whole department. I have often noticed with pleasure the eagerness with which the steam diagrams have been examined; the interest taken in the development of the horse-power; the pleasure expressed at the good vacuum in one set of engines, and the disappointment at the comparatively bad vacuum in the other set; the determination of the one party to maintain the good vacuum in the one set, and of the other party to find out and remedy the defect which caused the bad vacuum in

the other set of engines. This feeling should be encouraged, even, as has been said, down to the stokers, for it makes all take an interest in their special work. The best and most useful work is always performed by men who take an intelligent interest in and *like their work.* There is always in all men some capacity for doing good work, and he is the best officer who, by tact and skilful management, succeeds in getting the greatest amount of this good work out of every one of his men.

In proposing the telling off of certain men to care for special parts of the machinery, I of course do not mean that in case of emergency these men shall be considered unavailable for service in other parts of the department. For instance, if serious defects arise in, say, the starboard engines, then undoubtedly a great part—or, if necessary, the whole—of the force should be brought to bear on the defective part, so that its efficiency might be restored as quickly as possible.

The great and important work of maintaining the efficiency of the machinery of every war-ship during commission by the ship's staff, without assistance from the dockyards, is surely worthy of very earnest effort by engineer officers, for if it could be done two very important results would follow, viz.—

1. It would much improve the engine-room staff in every ship, by increasing their confidence and professional ability, making them more careful in management, and quicker in detecting and making good small defects before they grew into big ones; it would create a spirit of emulation among the whole of the members

of the steam branch of the Navy; and, above all, it would, it may be hoped, exorcise the spirit of helplessness which is induced by the knowledge, that every little defect that arises can be turned over to, and be made good by the dockyards.

2. As to the dockyards: It would save expense by rendering unnecessary the intermittent and continuous repairs of ships in commission, and would enable them to devote more time and attention to the building of new ships, and to the refitment of ships in the Second-class Reserve being brought forward for another commission.

Of these two results much the more important is the first. To make the fleet men, from the highest officers to the lowest ratings, more competent, capable of keeping their ships during commission in a high state of efficiency without assistance from outside, is indeed worthy of attempt by all naval engineer officers who take pleasure in their professional work, and are proud, as all should be, of belonging to so noble a Service as the British Navy.

But I think I hear some able engineer officer say: "Suppose I do succeed in keeping my ship efficient during a commission, without any assistance from dockyards, would this service meet with adequate recognition and reward? From my experience I should say it would not." To this I might answer, that zeal for the Service should be a sufficient inducement; but I will not answer thus, because undoubtedly there is in naval, as in all other men, a great deal of human nature, which causes good men, who do good work, to wish for, and reasonably wish for, some tangible reward, in the

shape of official recognition and professional advancement. This brings me to the second part of this subject, which is, to ask whether there is any simple and easy way of differentiating the ability and zeal of some from other engineer officers, with a view to rewarding the most deserving? There seems to be a way, at once simple and easy, by which this could be done, if the proposition in the preceeding chapters be true, viz., that economy is a good measure of efficiency. Take the suppositious cases we have already referred to, of two large cruisers of the same class, tonnage, and engine-power, built and engined by the same firm.* Suppose they are commissioned the same day, and run through a commission of three and a half years, during which they each steam a distance of from 50,000 to 70,000 knots. It is not material that they should each steam the same distance, for the performances of the ships will be judged by averages at the end of the commission. But let us assume that both ships steam a distance of 60,000 knots during the three and a half years they are in commission. It will be remembered that it was supposed in a former chapter there was good engineering in one of these two ships, and bad engineering in the other, resulting in a loss of efficiency represented by a greater consumption of coal in the one ship as compared with the other, amounting to twenty per cent. Therefore, one ship will burn 50 tons, and the other 60 tons of coal for making a daily distance of 300 knots. And if we assume that this is the average

* *Vide* Part III., Chapter I., page 142.

performance for the commission, during which both ships steam 60,000 knots, we have this result—that the efficient ship burns 10,000 tons of coal, and the inefficient ship 12,000 tons, while making this distance. Therefore the efficiency of the economical ship is represented by a saving of 2,000 tons of coal, which, at the rate of thirty shillings per ton on a distant station, would amount to £3,000 during a commission of three and a half years. It should also be noted that it would be probable that the inefficient ship would be, more often than the other, in the hands of the dockyards for repairs, and the additional cost thus incurred must be added to the £3,000, if we wish to get a true estimate of the economy of the one as compared with that of the other of the two ships. It may be mentioned here also that to get a fuller measure of the efficiency of the ship in which there has been good engineering, two things must be taken into account. First: That at any time during the commission the highest rate of speed can be attained, and the greatest engine-power developed, which could not be done in the inefficient ship. Second: On the ship paying off, the machinery would be in excellent order, resulting in lessening the time and largely reducing the amount usually required (in the case of inefficient ships) for refitment for another commission.

On the whole, economy in consumption of coal is a fair measure of efficiency as regards naval engineering, and, if so, it follows that the relative efficiency of similar ships during their commissions can be easily ascertained by a reference to the engine-room registers,

from which the necessary particulars could be taken and the averages calculated. In these registers the engineers in charge should be required to note the cost of repairs by dockyards for labour, the information being given for this purpose by the dockyard officials on the completion of every repair.

At the end of the commission of every ship her performances should be abstracted from the engine-room registers, the main particulars required being—

Total distance steamed	Knots.
Coal burned for obtaining this distance	Tons.
Average speed per hour	Knots.
Cost of repairs by dockyards	£

In the case of the two large cruisers already referred to, if we suppose the cost of repairs by dockyards during the commission of three and a half years is £50 in the efficient ship and £250 in the inefficient ship, the record on paying out of commission would be as follows:—

		EFFICIENT SHIP.	INEFFICIENT SHIP.
Total distance steamed	Knots	60,000	60,000
Coal burned for obtaining this distance	Tons	10,000	12,000
Average speed per hour	Knots	12·5	12·5
Cost of repairs by dockyards... ...	...	£50	£250

Assuming that the average price of coal per ton on a foreign station is thirty shillings, we have:—

	EFFICIENT SHIP.	INEFFICIENT SHIP
Cost of coal	£15,000	£18,000
Cost of repairs by dockyards	£50	£250
Total...	£15,050	£18,250
Difference	£3,200	

Thus the efficient ship has done the same work, during the commission of three and a half years, for £3,200 less than the inefficient ship, and this has been caused entirely by the good engineering of the officer in charge of the machinery of the efficient ship, for it will be remembered that the assumption was that the two ships were of the same class, tonnage, and engine power, built and engined by the same firm, and thus commencing the commission under the same conditions.

It has thus been shown that from very simple data, which can be obtained immediately after paying off, from the engine-room registers, the expense incurred by every ship during a commission can be calculated. It would be well for the results to be recorded on a suitable tabular form, and kept at the Admiralty, as a material part of the history of every ship, for if this be done the *actual* performances of all similar ships during their commissions could be easily compared. If it be true that economy is a fairly good and complete measure of efficiency, it will be easy to ascertain the relative efficiency of similar ships during their commissions, and to single out those engineer officers who have, in the best possible way—*i.e.*, experimentally—given conspicuous proof of great attention, ability, and zeal in carrying out their important duties.

As to the possibility of the machinery of all ships during commission being kept in an efficient condition by the ships' staffs, without assistance from dockyards, I mentioned in an early part of this chapter that I had acted with some success on my views in this matter during a service of nearly forty years in the Navy, and

I propose to illustrate this by giving a page out of my Service history, observing that I do so only for purposes of illustration.

In December, 1857, when little more than twenty-five years of age, I was appointed as the engineer officer in charge of machinery of a small war-ship in China, one of the larger class of screw gun-vessels.* She was in commission between four and five years, paying off in January, 1862, at Hong Kong. The vessel was very actively employed nearly the whole commission, for England was at war with China a great part of this time. She was employed on various services, running the mails between Hong Kong and Canton; present at the bombardment and capture of the latter city; also, later on, at the capture of the Taku Forts at the entrance of the Peiho River; took part in the destruction of a large number of piratical junks and armed stockades on shore; and was for more than a year surveying parts of the coast of Japan. On one occasion my vessel towed two gunboats nearly the whole way from Hong Kong to Shanghai, nearly 1,000 miles. I mention these things to show that the ship did a very great deal of work during the time I served in her, the work being done mostly while under steam, involving a large amount of wear and tear to the steam machinery. The vessel had been in commission for nine months before I joined her, my predecessor having been invalided for the preservation of his life. I mention this because I was not responsible for anything done before December, 1857. From that date till January, 1862, just over four

* "Algerine."

years, the efficiency of the machinery was maintained by the ship's staff, and not a single dockyard-man ever came on board to do any work, though the ship was frequently anchored within two hundred and fifty yards of Hong Kong Dockyard, in which there was an excellent plant and every appliance for making good machinery defects. Now the question is: How was this great work accomplished? I answer: By the plan proposed in the earlier part of this chapter. I invited my junior officers to meet me, and explained my plan. To each of us—I did not leave myself out—was assigned certain parts of the work of the whole department. I put it to them that, having once put our hands to the plough we must not look back. After consideration they agreed, and, more important still, most loyally carried out their duties, never once complaining while in the ship, which was less than two years, for, the vessel in this respect having made a name for herself, they were, I am pleased to say, promoted into other smaller ships in charge of machinery.

Their successors in my ship naturally took over their duties, and thus this work was carried on during the whole commission. As regards my junior officers, who were promoted into other ships, we, of course, often met afterwards; and I am glad to remember that they adopted the same plan, and maintained the efficiency of the machinery of their vessels without assistance from the dockyard.

One of the details of the system pursued in my ship was that just before arrival in port we met, and in conversation decided what should be done in the

way of repairs while in port. This work, and only this work, was done, and then the ship was reported ready for service again, the officers having nothing further to do except taking their regular turns of "duty officers" for certain days. Now the singular result of this system as regards both officers and men was, that though there must have been a great deal of useful work done, yet leave and other privileges were enjoyed to a greater extent than by those in other ships. As one of the men said, "When work is done it *is* done, and then we have easy times."

But some may say, "Perhaps the machinery was so good that very little repair was necessary." I may answer that this was not the case. I will give an instance. In 1858 a very serious defect developed itself in the crank shaft of the main engines, and it was necessary that it should be made good without delay. A *Requisition* for time—six days—was sent to the Commander-in-Chief. It was immediately granted. A *Demand* was made for material from the dockyard, and it was at once supplied. The repair was done by the ship's staff, the whole force being brought to bear on it; the crank shaft was disconnected and hoisted upon the upper deck, the work was done, and the shaft was in its place again on the evening of the fifth day, and thereafter, for the remainder of the commission, *i.e.*, for three years, gave no further trouble. One incident in connection with this it is pleasant to recall, as showing the keen interest taken by the Commander in the carrying out of this big repair by the ship's officers and men within a few hundred yards of Hong Kong

Dockyard. During the five days he frequently took off his coat and assisted in doing the work, and seemed to enjoy the novelty of the employment. About twenty-nine years of age at this time, he was one of the best mathematicians on the China station, and an excellent amateur engineer. He was the Lieutenant in command—William Arthur, the late Rear-Admiral of that name. I may mention that, excepting the times the machinery was under repair, for doing which time was asked for and always granted by the senior officer, the vessel was at all times ready for service and thoroughly efficient. Indeed, she was a favourite vessel of the Commander-in-Chief, who made a kind of second tender of her to his flagship. It is some proof of this that during the commission three Lieutenants in command were promoted, and a fourth would have been but for some mischance which prevented it for a time. I have already remarked that several junior engineer officers were promoted, and appointed in charge of the machinery of small ships. I have now only to state that I likewise received two promotions in substantive rank, returning home in 1862, while still under thirty years of age, with the rank of Chief Engineer. I mention this because it is to some extent an answer to the question asked by an officer* as to whether, if he succeeded in maintaining the efficiency of the machinery of his ship during a commission with the ship's staff, without any assistance from dockyards, this service would meet with official recognition and reward. It appears that

* *Vide* page 167.

it did so in those days of which I write, and, I doubt not, would in the present day.

But some may say: "No comparison can be made between the steam machinery of 1860 and that of the present time; there is now much more of it, and it is of a more complicated description, and therefore thirty years ago efficiency could be more easily maintained than at present." I grant this fully; but as a set-off to this it must be stated that in those days there were no engine-room artificers nor stoker mechanic ratings of any kind; and this it will be admitted was a heavy drawback, causing the officers of those days to be seriously handicapped as compared with the officers of the present time.

It is hoped that it has been proved that it is possible for the efficiency of the steam and other machinery of every war-ship, during commission, to be maintained by the ship's staff without any labour assistance from dockyards, and proved in the most convincing way, viz., by a reference to facts. I might adduce other instances—for I have carried out this system with success in many of the ships in which I have served—but I forbear. One illustration will suffice.

There is no doubt that if this great work could be successfully done by the fleet officers and men, without outside assistance, it would be of incalculable advantage to our modern steam Navy. Should not, therefore, every means be used to attain this end? Firstly, by the adoption of the proposed or similar plan; secondly, as proposed in the second chapter.*

* On the subject of the Steam Reserves being used as schools of instruction for fleet mechanic ratings, see next chapter.

on this subject, by the efficient training of all fleet mechanic ratings while serving in the Steam Reserves, in the work of general machinery repairs now done by dockyards ; and, lastly, by the exhibition of thoroughly good naval engineering on the part of the engineer officers of the fleet, this being, perhaps, the most important, for without it no success can reasonably be looked for.

CHAPTER IV.

NAVAL ENGINEERING IN WAR-SHIPS.

Steam Reserves on the home stations considered as schools of instruction and training of fleet mechanics in practical engineering work—To make them more competent than at present to maintain the efficiency of the machinery of all ships in commission without assistance from dockyards—Attached to every Steam Reserve are a supervision staff of officers and petty officers, and shops of all kinds, fitting shops, turneries, smitheries, foundries, machines worked by steam engines, and material and stores—Kinds of work done by Steam Reserve staff—Ships in fleet and other classes of Reserve—Repairs to steam launches, pinnaces, and cutters—What should be done to get the greatest possible benefit from the Steam Reserves in improving the mechanical ability of the fleet mechanics?—Answer—Suggestions in detail—Proposed plan—Necessary to strengthen the Reserves by entering 180 additional engine-room artificers—Reference to the skilled labourers of the Service—Chief and leading stoker mechanics—How the plan would affect them—Result of the operation of the plan as affecting all mechanic ratings—As to measuring the amount of useful work done by good engineering—A simple plan by which all good work done, which would otherwise be unnoticed, might be placed on record—Two sorts of forms required for lists of defects—When dockyard assistance is required and when it is *not* required—Differences in these forms explained—Forms numbered thus: Defect list, No. 1: Defect list, No. 2—No. 2 to be used when the ship's staff would do the work, for which the necessary time would be granted during which the ship would not be available for service—Local authorities on the recommendation of the professional officers to have the power to order the commencement of work without reference to the Admiralty—Reasons—How the employment of the Steam Reserves, and the establishment of another form of defects list, as proposed, would affect the naval engineering of our war-ships—How this would be ascertained and measured, 1, 2, 3—Reward of exceptionally meritorious service—Quotation from a review of Nava Engineering, by one of the Service journals.

IN the second chapter* it was suggested that the Steam Reserves should be used as schools of instruction for the improvement of the fleet mechanic ratings in practical engineering work. It was there stated that, attached to every one of the three home Steam Reserves, there were workshops, composed of fitting shops, turneries, smitheries, foundries, and every appliance necessary to making repairs of machinery of every kind, except those exceeding a certain size and weight. Also there are steam-engines for the purpose of driving the machines of all kinds which are fitted in these Steam Reserve workshops. In every Steam Reserve a fleet or staff engineer is appointed specially to superintend and be responsible for all work done in the way of repairs or new fittings; and under this officer there are several engine-room artificers, mostly of considerable service and experience, to look after the younger men and instruct them in the fleet work being done in the Reserves. These older men are on the permanent staff, and thus are not liable to be drafted to commissioned ships till they have served a stated time in the Reserves. They are mostly chosen from the best men, coming into the Reserves on the paying-off of their ships after a commission on foreign service, and in this way get a spell of home service. There are also specialists, such as moulders, pattern makers, and such like, who are permanently attached, and do not serve in commissioned ships, except in very large flagships, and sometimes in foreign dockyards.

Thus the Steam Reserves are well equipped, and thoroughly competent to carry on at any time the work

* Pages 151 and 156.

of assisting to make the repairs of machinery of commissioned ships, and of those fitting out for commission. There are officers, mechanic instructors, specialist mechanics, workshops of every kind, fitted with all descriptions of machines, driven by steam engines, and large stores of material always at hand either in the Reserve stores or in the adjacent dockyard. Finally, many of the senior engine-room artificers are excellent workmen, well able to instruct the younger ones, and at the same time to usefully assist the dockyards in doing the repairs to engines and boilers, and making good machinery defects of every kind. It should be mentioned that each Steam Reserve—the steam branch of it—is under the immediate direction of a Chief Inspector of Machinery, who is, generally speaking, an officer of great ability and experience, selected from the senior engineer officers on the Active List of the Navy.

Now there are two kinds of work done in the Steam Reserves by the fleet mechanic ratings:—

1. The work in connection with the care and preservation of the machinery of ships in charge of the Steam Reserve.
2. Work in connection with small machinery repairs done to ships in commission, steam launches, pinnaces, &c., &c.

As to the first, viz., the care and preservation of machinery in charge of the Reserves: When the machinery of a ship has been thoroughly repaired and refitted by the dockyard, and the ship is otherwise ready for commission, she is passed into what is called

the Fleet Reserve, a skeleton crew is placed on board, which will go to sea in the ship when commissioned, and the ship is ready at short notice for commissioning. The skeleton engine-room complement, composed of officers, mechanic ratings and stokers, henceforth do the work of care and preservation of the machinery, which, already in a highly-efficient state, does not require any repairs of a nature to improve the men in mechanical ability.

Again in ships when the dockyard ceases, temporarily or otherwise, to do work on board, the Steam Reserve takes charge, and sends a small staff on board, to see that the defective machinery does not further deteriorate, and to care for and preserve the engines till again taken in hand by the dockyard. Here again it is evident that in these ships there is no improving work of any kind to be done by the mechanics of the Reserve.

Besides the men employed in the two classes of ships named, there are others who are employed in the Steam Reserve workshops doing repairs to the machinery of steam launches, pinnaces, cutters, &c., &c., but this work is not as improving as the repair of large machinery would be, and moreover the number of men employed in this way is so small that it is doubtful whether the fleet mechanics as a whole are much benefited by doing this work.

Therefore it will be seen that the large majority of the fleet mechanics in the Steam Reserves are employed in the care and preservation of machinery, and not in doing improving repairing work; and that a smaller

number of men are employed in doing minor repairs to small engines, which does not very much improve their mechanical ability.

But as there is every appliance in the Steam Reserves, and an ample supervising staff, it is evident that we already have in the Steam Reserves splendid training schools for perfecting the ability of the men who will have to serve in our ships at sea, and who could do so much to further the great work of maintaining the efficiency of the machinery of all ships during commission without help from the dockyards. In this way these men would be able, under the officers, to practise that thoroughly good naval engineering necessary to gain this great end.

What then should be done in order to get the greatest benefit possible from the Steam Reserves as schools of training for the fleet mechanics in high-class repairing work, and thus make them more fit to make ships in commission self-supporting? In answer to this the following suggestions are made :—

The fleet mechanics (engine-room artificers and stoker mechanics) attached to each Steam Reserve should be divided into two classes, viz.—

1. The men appropriated for the care and preservation of machinery of ships in charge of the Steam Reserve.
2. The men being trained in the Steam Reserve workshops in the general work of repairing and refitting the machinery of ships being brought forward for commission.

As to the first : The men included here would be in

number about equal to the whole of the men now employed in the Steam Reserves. They would be men liable to be drafted to ships on commissioning and to first Reserve ships, and for the general service afloat. They would be those who had completed their term—*vide* 2—in the workshops, and on the roster for draft when wanted, and for duty in the Fleet Reserve ships as skeleton crews, and for any other "care and preservation duties" they would be required to do.

As to the second; These men, who should in number be not less than 60 in each Steam Reserve, would be employed in the Steam Reserve workshops, doing repairing work of the description already mentioned, viz., assisting the dockyards in refitting the machinery of ships being brought forward for commission. This service should be for not less than one year, nor more than two years. During this time they should be considered not available for draft or for any other service than the workshop service, except, perhaps, for a few weeks in ships mobilised for summer manœuvres. They should be composed of two classes of men; first, of newly-entered men; second, of men paid off from ships after a commission, whose mechanical ability required improvement by practice in the better kind of repairing work.

When either of these two classes of men had served from one to two years in the Steam Reserve workshops they would be available for service afloat, and would contribute a very efficient contingent towards carrying on the work of the naval engineering of commissioned war-ships.

But it is evident that to do this the Steam Reserves require to be strengthened. It would require at least an entry of 180 additional engine-room artificers in the Navy, for the number at present leaves no room for the appropriation of men for training in naval engineering afloat—men, it must be repeated, who should not be liable to be detached for any other service except, perhaps, for temporary service, when mobilisation takes place.

The skilled labourers of the naval engineering service, viz., the chief and leading stoker mechanics, would be much benefited by this employment in the Steam Reserve workshops, because they afterwards would be able to take a much larger and more intelligent part in the repairs of machinery when serving afloat. It would also increase their efficiency as watch-keepers, for they would have a greater knowledge of the various parts of steam-engines by having to take a part in the disconnection, repairs, and reconnection of all descriptions of machinery.

Thus it has been shown that the efficient training of fleet mechanic ratings for service in the fleet could be carried out :—

1. By entering additional men of the engine-room artificer class.
2. By giving to the Steam Reserves some of the better kind of repairing work now done by dockyards.
3. By always having a number of fleet mechanic ratings in each Steam Reserve, not fewer than 60, who should be employed exclusively in the

workshops making good machinery defects; these men so appropriated not to be considered available for draft, or for any other duties, except when the summer mobilisation takes place.

As we have at present the necessary plant and the staff of supervisors and instructors, all that is wanted is additional men, and the allocation of the necessary work, and of this it may be remarked that the additional expense incurred by the entry of the 180 additional engine-room artificers would be in great measure met by the value of the work done by these men, and the outcome of the scheme would be, that we should have at all times a large number of highly-trained mechanics available for service in the Fleet. These men would be thoroughly well up in practical naval engineering, and competent to carry out the great work of maintaining unassisted the efficiency of the machinery of all ships in commission. Thus fleet men would be able in every respect to meet all fleet requirements.

In the preceding chapter a plan was proposed by which the exhibition of good naval engineering during a commission could be ascertained and recorded, with a view to the recognition and reward of the most deserving of our engineer officers. But it is possible that much very important and useful work might be done by the ship's staff during a commission, and almost lost sight of; and thus the amount of this useful work would never be known. Efficiency would indeed be maintained by the ship's staff, but whether the actual work done were *much* or *little* would never be known,

except by a minute examination of the engine-room registers, which are probably seldom very closely examined when things go well. It is when things do *not* go well that the registers are examined as to the detailed proceedings of ships.

Now there is a very simple way of placing on record the work done in a ship, whether by the ship's staff or by the dockyards; this latter is already recorded on the list of defects. On this list of defects—a printed form—the defects are enumerated and described by the officer in charge of the department of the ship in which the defects arise. On the first page of the defect list form, the Captain and the departmental officer make and sign a declaration that the defects exist, and that they cannot be made good without assistance from the dockyard. Thus all defects made good on board by the ship's staff are shut out, and these frequently keep the fleet men busily employed the whole of the time the ship is under repair. I have frequently known the dockyard and other officials, when examining defects lists, ask "What are the ship's men about? Why cannot they do some of this work?" The Admiralty officials are specially liable to ask such questions, not thinking perhaps, because not knowing, of the large amount of work done by the staff of the ships concurrently with that done by the dockyard people. Now there seems to be a very easy and simple method by which this large amount of work, quietly done by the ship's men, could be placed on record, thus preventing the questions referred to being asked, and also ensuring the ship's staff being credited with the doing of this work.

There should be two sorts of defects lists. One a list, called No. 1, of those defects which *cannot* be made good without assistance from the dockyard; and the other, a list, called No. 2, of those defects which *can* be made good without this assistance. On this last list the dockyards might supply material, and the officials, on examining this list, would concern themselves only as to whether the material asked for was wanted. In the other case they would of course concern themselves with the existence and nature of the defects, and how far it was necessary to make them good.

When these two defects' lists were completed and signed by the officials concerned they might be forwarded to the Admiralty, by whom they could be approved or not; but, in any case, the Admiralty officials would see both what the ship's staff *could* and *could not* do without assistance, and they would be officially credited with the work it was proposed they should do.

This, of course, would only be necessary when a ship was entering a port in which there was a dockyard. When cruising with a fleet, or serving on a foreign station, the record in the engine-room register would be sufficient.

Even in the case of a ship entering a port, and requiring repairs, which, however, could be done by the ship's people, it would be useful to send in the defect list No. 2, for on it material would be obtained, and, what is of more importance, *time* to do the work would be granted, during which the ship would *not* be available for the ordinary service. When a big repair is to

be done by the ship's staff it is absolutely necessary that time to do the work should be secured. The disconnection and reconnection alone—which is no part of the repair proper—often take a considerable time, and it therefore is essential that time should be officially obtained, which could be done by sending in the Defect List No. 2, and Admiral Superintendents of the dockyards should be authorised to grant this time at once, on the recommendation of the local officers, to prevent the delay a reference to the Admiralty would cause.

It will be seen that the two subjects dealt with in this chapter have a very material bearing on naval engineering in our ships of war.

1. The use of the Steam Reserves as schools of instruction and training of all fleet mechanic ratings, so as to make them more competent than at present to carry out, under their officers, the great work of maintaining the efficiency of the machinery of war-ships during commission, without assistance from dockyards; in short, to make commissioned ships self-supporting by the ability of the fleet men to meet all the wants of the fleet.
2. To have a simple and easy means of placing on record, and crediting the ships with, all work in making good defects done by the staff of the ships without assistance from dockyards, except the supplies of material.

Thus, at the paying off of every ship, the naval engineering, whether good or bad, exhibited by the engineer officers during the commission might be easily ascertained :—

1. By the "economy" test as explained in the preceding chapter.
2. By the condition of the machinery on paying off.
3. By the actual work done as shown by the several lists of defects, and the record in the engine-room register.

And in this way the officers who do well in respect of their naval engineering will stand out from others, and their services will deserve, and no doubt receive, ample recognition and reward.

In concluding these chapters on naval engineering, I cannot do better than quote a Press notice of the first chapter * by one of the Service journals:—

"Naval engineering includes not only the care of the propelling engines, but also of the great amount of auxiliary steam machinery now fitted; of the hulls of ships, and their very numerous pipe, valve, and other connections; of torpedoes and electrical machinery; of hydraulic and other machinery connected with guns and their fittings, and very much more. When this is remembered, it may be truly said that naval engineering will be a most important factor—perhaps *the* most important factor—in the Navy of the near future."

* It appeared as an article in the *United Service Magazine*, December, 1891, and was reviewed by the *Naval and Military Record*, of the 3rd of December, 1891.

PART IV.

MISCELLANEOUS.

PART IV.

CHAPTER I.

THE COAL ENDURANCE OF HER MAJESTY'S SHIPS.

A.—*Single Ships of War.*

Naval manœuvres, 1890-91—Attention directed to coal endurance of war-ships—Present estimated coal endurance inaccurate—Probable causes of miscalculation—Data from which this was made—Resistances not sufficiently taken into account—Also coal used for other than propelling purposes ignored—Hence coal endurance has been over-estimated—Reference to large amount of auxiliary steam machinery now fitted in ships—Working which heavily taxes the coal supply—What affects coal consumption for propelling purposes—Resistances—Always varying in degree—Discrepancy between the calculated and actual distances ships can be steamed with their coal stowage—Plan, simple and inexpensive, proposed for obtaining the *actual* coal endurance—By experiment—Plan illustrated by taking a battle-ship with a coal stowage of 1,000 tons—Experiment to be carried out with the average weather at sea—Classes of ships—Every ship when first commissioned should carry out the proposed experiment—Also at the beginning of every succeeding commission—Reasons—Experiment need not be continuous; would not cause any expense; and would not interrupt the general service of ships—Value of correct coal endurance to Captains of ships and Commanders-in-Chief of fleets—Necessity for testing by actual experiment all matters of doubt—Because of the difference between *actual* and *estimated* performance.

B.—*Sea-going Fleets and Squadrons.*

Coal endurance of sea-going fleets of more importance than that of single ships—Reasons—Conditions under which modern fleets can keep the sea—Altogether different to those of former days—Abandonment of sail-power and substitution of steam-power—Results—What determines the *duration* of the efficiency of fleets at sea?—Coal endurance

—Necessary to keep a reserve of coal to take ships into the nearest port to replenish—This reserve coal not available for keeping the sea —Remaining coal only available; proving the necessity of adopting some plan for keeping an efficient coal supply—Remarks on present practice—Its prejudicial effect on the war strength of sea-going fleets —Enquiry as to whether the coal endurance of all war-ships could not be made approximately equal—Relation between horse-power and tonnage—Coal consumption following horse-power—Examples of two battle-ships, one with a coal endurance of 8,500 knots, the other of 5,000, ascertained by calculation—Is this good for the Service—If not an attempt to equalise, as far as possible, the coal endurance of all ships should be made—Illustration of the great importance of the coal question afforded by summer manœuvres, 1890—Remarks on this and deductions therefrom—Four definite plans proposed for keeping up the coal supply of sea-going fleets, so as to enable them to keep the sea for months, instead of days, as at present—Two of these plans preferred in combination—Remarks on the effect produced by the operation of the two proposed plans—Adoption of plans would make it unnecessary to provide armed convoys for colliers in war time, and fleets could be kept up to their full strength —Question of expense considered—The exact value of coal in relation to the continuous efficiency of sea-going fleets—Two questions asked—Are the proposed plans practicable?—Is the object aimed at desirable and necessary?—Conclusion.

A.—*Single Ships of War.*

THE naval manœuvres in the summers of 1890 and 1891 directed attention to the subject of the coal endurance of Her Majesty's ships, and have shown that the number of knots vessels are capable of steaming at a given rate—say ten knots—with the full quantity of coal stowed in the bunkers, have been considerably over-estimated. It is probable that the distance vessels can steam at a ten-knots' speed has been calculated from the consumption of coal during the four hours' trial at full power, and the distance gained during that time. This calculation has been made, it would seem, on the assumption that the circumstances under which ships would steam the whole

distance at a ten-knot speed, would be the same as those on the four hours' full-power trial, viz., with a smooth sea and a moderate force of wind. Consequently, the resistance to a vessel's progress due to the state of the sea, and the force and direction of wind, has not been sufficiently taken into account. Also, it is probable, that the coal used for purposes other than propelling the ship has been ignored, and this would add considerably to the discrepancy between the calculated theoretical distance and the real distance a vessel could steam with her total coal stowage. Thus, as regards this coal, it is probable that from one to six tons are daily used, according to the size and description of vessel, for working the auxiliary machinery, and entirely in addition to that used in making a distance. We have now in some of our large ships more than sixty complete steam engines, some of which are nearly always at work; and while this makes it possible for the ships' companies to be largely reduced in numbers, it imposes a heavy tax on the coal supply. But this is a pretty constant quantity, and can be easily taken into account in calculating the distance a vessel could steam at a given rate with a fixed quantity of coal. As regards that used for propelling purposes, what chiefly affects consumption is, the resistance to the ship's progress due to immersion of ship, state of sea, force and direction of wind, condition of bottom of ship, &c., &c., and these are always varying in degree. On the whole, it is nearly certain that in calculating the distance a vessel is capable of steaming at a ten-knot speed, the calculation has been made on the assumption that the whole of

the coal stowed is available for propelling purposes. From this, and because of the resistances to the vessel's progress through the water varying continually, neither of which has been sufficiently taken into account, arises the discrepancy between the calculated and the actual distances ships are capable of being steamed at a given speed, with the coal stowed in the ship's bunkers.

As the theoretical calculation has failed to give us information on which we can rely as to the distance ships can steam with their coal stowage, it may be asked whether there is not a better way of ascertaining this most valuable part of the capabilities of a ship of war, the part, indeed, on which the continuous efficiency of the whole ship depends. Fortunately, there is a way at once simple and inexpensive, which will give the *actual* distance any ship can obtain at a given rate with her coal stowage. The proposed way is by actual experiment. For the purpose of illustration we will take a battle-ship with a coal stowage of 1,000 tons. What is wanted is the distance the ship will steam at a ten-knot speed with 1,000 tons of coal, *less* the quantity required for other purposes, while the distance is being made. The ship is commissioned and ordered to join the flag on a foreign station. From the time she commences her outward voyage she makes her distances at a speed of ten knots. During the time these distances are being made, an accurate account must be kept of the coal expenditure, as, *e.g.* :—

1.—Coal used for propelling the ship		tons.
2.—Coal used for all other purposes		tons.
	Total...	tons.

It will be noticed that this experiment to be satisfactory need not be continuous ; it might be carried on for two days, and discontinued for a week ; also the ship might be coaled half-a-dozen times while the 1,000 tons are being consumed. All that is wanted is that an accurate note be taken of the times—the number of hours each time—the experiment is being carried out, and the coal used for all purposes during those times. When the vessel has been steaming—not, as before remarked, necessarily continuously—at the ten-knot speed, so long as to make the quantity of coal consumed reach 1,000 tons, the experiment ends, and the distance in knots made during the consumption of this coal may be got from the ship's log, and recorded as the *actual* distance the vessel can steam at a ten-knot speed, with the full coal stowage, viz., 1,000 tons.

It may here be remarked that it would be well for the experiment to be carried out with the *average* weather experienced at sea. For instance, it would be undesirable to steam during any part of the time against a heavy head-wind and sea. Perhaps the chief limit necessary is that the wind, when ahead, should not exceed a force of 3. If it should exceed this force the experiment should, for a time, be discontinued, the weather not being the average experienced at sea.

The battle-ship with a coal stowage of 1,000 tons has been taken to explain how, with ease and simplicity, the coal endurance might be ascertained by actual experiment, and this plan might be adopted in all ships with equal ease and certainty in the trustworthiness of the results. But while vessels are new, and before

being commissioned, an approximation to the steaming capabilities of all ships of war might easily be made. Our ships are, generally speaking, divided into classes —*e.g.*, the classes of battle-ships and cruisers, each class being often composed of vessels of about the same tonnage and horse-power. There might be one ship— when commissioned—to experiment with, on the plan proposed, and the performance of this ship might be taken as the possible, and even probable, performance of the whole of the other ships of her class with the same horse-power and tonnage. It is considered that this plan, viz., founding the coal endurance of a whole class of ships of the same tonnage, horse-power, and coal stowage on the performance of one ship of the class, *by actual experiment* would give a much closer approximation to the coal endurance than by the present method of calculation. There is, however, no doubt that the performance of similar ships on actual trial very often vary in a remarkable manner under apparently similar conditions and circumstances. There is also, in many vessels of the same class, important differences in respect of horse-power, coal stowage, tonnage, &c. Therefore, as the actual steaming capabilities of every ship are so easily got by experiment, with no material interference with the ordinary service of the vessel, it is considered that every ship when commissioned should, early in the commission, carry out this experiment with a view to placing the result on record at the Admiralty and on the ship's books. It would be well if the experiment were also made at the beginning of the second and third commissions,

for it would infallibly show any variation in the efficiency of a ship during her future life, and if there was a loss of efficiency the cause might be ascertained and remedies applied. As has been remarked, the performance of all ships, new and not yet commissioned, might be calculated from the average performance of all other ships of the same class, tonnage, and horse-power which have gone through the experimental trial. This would give a fairly correct idea of the steaming capabilities of the new ships until there was an opportunity of ascertaining this accurately by actual experiment.

Thus, in the case of single ships, a plan has been proposed, by which in every ship the coal endurance can be ascertained by experiment at sea, the coal endurance being measured by the actual distance obtained with the coals stowed in bunkers, at a speed of ten knots. Further, this experiment can be carried out with no expense, and with no interruption of the general service in which the ships may be employed.

The information thus obtained would be most valuable to the Captains of ships, as well as to Commanders-in-Chief of fleets and squadrons, and would be an accurate measure of the duration of the efficiency of ships at sea, so far as their coal-carrying capacity is concerned. In this, and all other matters of doubt, it would be well to test, when possible, by actual experiment, which will always give more accurate, and therefore more valuable, results than any obtained by theoretical calculations. This would appear to be more especially necessary at the present time, when the *actual* falls sometimes

very short of the *estimated* performance of modern ships and machinery.

B.—*Sea-going Fleets and Squadrons.*

The coal endurance of sea-going fleets and squadrons is a subject of even more importance than that of single ships, because it involves the important consideration of how long a fleet or squadron of war-ships, acting in combination, could keep the sea in time of war. It must be remembered that, in these days, the conditions under which fleets can keep the sea are altogether different to those that obtained in former days, when naval battles were fought with sailing-ships, which, provided there was a sufficient store of ammunition and food, and masts and rigging were in fairly good order, could keep at sea for an unlimited time. At the present time, in modern battle-ships and cruisers, sail-power has practically been abandoned, and the time war-ships could keep the sea is determined by their coal endurance. The importance of this will be at once seen, when it is considered, that the continuous efficiency of ships of war depends absolutely on the coal being sufficient to enable them to perform the service required, when operating against hostile fleets at sea; and in this connection it must not be forgotten that fleets at sea must not let their coal supply run down beyond a certain limit, *i.e.*, there should always be reserved in all ships sufficient coal to take them into the nearest coaling station to replenish. This quantity kept in reserve should, therefore, it is clear, not be considered as available for keeping the sea, and acting on the offensive against the

enemy, and therefore it should be deducted from the full quantity of coal stowed; and when this is done it will be seen that the coal really available for keeping the sea is much diminished in quantity, and it brings home vividly to us the vast importance of the whole coal question as affecting the time a British fleet could keep the sea in a time of war. It may be said here that the Commander-in-Chief of a fleet might, as his ships fell short of coal, send them, a few at a time, into the nearest coaling station to fill up and return, and perhaps this is at present all that could be done; but it is considered that this constant depletion of the war strength of a fleet would operate very prejudicially, and make the number of efficient ships acting in combination very uncertain. Therefore it would be well to endeavour to obtain a more excellent way than that to keep up the coal supply necessary to enable a fleet to keep the sea. This will be considered more fully by-and-bye; meanwhile another view of the coal question is opened up now, viz., whether it would not be possible, and if so, very beneficial, to so arrange the coal stowage of war-ships as to make the coal endurance of all vessels of the same class approximately equal? And this might be extended by making all classes of battle-ships and the belted cruiser class have also an equal coal endurance. Indeed, it would be well, so far as possible, to carry this out in all war-ships, from the first-class battle-ship to the small cruiser. There is generally a relation between tonnage and horse-power, and, roughly speaking, coal consumption follows the horse-power. This appears to be a reasonable suggestion. At present

we have one vessel with a coal endurance which, *by calculation*, enables her to steam at a ten-knot speed a distance of 8,500* knots, and in another ship 5,000† knots only can be obtained at the same speed, and under the same circumstances, *both ships being battle-ships.* Would not the fact of a fleet of ships having, as nearly as possible, the same coal endurance, make it easier for a Commander-in-Chief to arrange with more certainty than at present the nature of the service assigned to the various ships composing the fleet? If so it would be well to attempt in future to equalise the coal endurance of all ships, but more especially that of battle-ships and first-class cruisers, which will have to bear the brunt of future naval battles.

An illustration of the serious importance of the coal question, as affecting the continuous efficiency of war-ships at sea, was afforded by the results of the summer manœuvres of 1890. It appears that the attacking fleet steamed away from Ireland for a distance of about 1,500 miles, at an average speed of eight knots. When the ships reached the rendezvous it was found necessary on board many, if not most of them, to take in more coal; and this was done, three colliers having been sent for the purpose to meet the fleet at the rendezvous. What does this show? It shows, first, that the coal endurance, as measured by the distance ships could steam at a ten-knot speed, with all the coal which could be stowed on board, had been considerably over-estimated; and secondly, that when the ships had arrived at the rendezvous, after a passage made at the moderate

* *Rodney.* † *Royal Sovereign.*

speed of eight knots—which was in favour of an economical expenditure of coal, as against a ten-knot speed—it was found that, allowing for sufficient coal to take the ships to a coaling station to replenish, there was practically little or none left to enable the fleet to keep the sea and act on the offensive against an enemy. In connection with this, it must not be forgotten that the three steam colliers would, in a time of war, have had to be attended by a powerful armed convoy, for in future wars the richest prizes that can fall into the enemy's hands will be ships laden with coal, which will be of priceless value to sea-going fleets and squadrons.

From the foregoing it will be seen that the question of keeping up a supply of coal to fleets and squadrons, so as to enable them to keep the sea for long periods, is of primary importance, and the subject deserves the most thoughtful consideration, with a view to deciding on the best and most practicable plan of effecting it. It is suggested that there are several plans by which this might be done.

1. By greatly adding to the number of coaling stations, especially where coal is likely to be most wanted, so that wherever a fleet of warships in a time of war may be cruising and watching the enemy, there might be, at no great distance, a base of operations for the supply of coal.
2. By having in attendance on every large fleet or squadron at sea one or two large ships, very fast, and armed with light guns, which would be capable of stowing several thousands of tons

of coal for the supply of the fleet, in addition to that required for their own use.

3. By fitting every ship, not now so fitted, with a small amount of sail power, auxiliary to the steam power, capable of sending the ships along, with a moderately fresh breeze, from two to four knots, according to the force and direction of the wind.
4. By attaching to every fleet one or two very powerful ocean tugs, which might assist ships falling short of coal into the nearest coaling station to replenish.

Though the third plan deserves thoughtful consideration, yet it is considered that the first and second plans in combination offer the readiest and the most feasible and practicable method of keeping up the supply of a sea-going fleet which has to keep the sea for long intervals. Let us see how these two plans would operate. It is assumed that coaling stations have been established, and especially in positions easily accessible to ships cruising near places where naval battles would in future possibly be fought between two or more European powers at war. Of course these coaling stations would have to be efficiently protected, about which, and the expense of doing it, more will be said by-and-bye. But with the establishment of these bases of operations for the supply of coal there would be a great advance made in the direction of maintaining the coal endurance of sea-going fleets and squadrons.

But what would make this thoroughly efficient would be the attachment to every fleet in time of war of one or

more of the large and fast steamships, with a great cargo-carrying capacity, which might be utilised for carrying coal. Such ships as the *City of New York* and the *Teutonic* would be admirably suited to this service. In addition to their own coal stowage, they might carry many thousands of tons of coal, which would be available for keeping up the coal supply of the fleet; and it is estimated that the two ships would do this service, and enable the largest fleet to keep the sea for months instead of days, as at present. These ships can steam twenty knots, and therefore could show a clean pair of heels to any enemy before whom it would be necessary to show the better part of valour. Also, if a hostile fleet hove in sight, and a battle was imminent, the two ships might proceed out of danger, wait the course of events, and return to the fleet when safe to do so. That ships can safely fill up with coal at sea was proved during the 1890 summer manœuvres, when, under favourable circumstances, many of the ships coaled from the steam colliers sent for the purpose. These large coal-carrying vessels might, one at a time, go to the nearest coaling station to fill up, and return to the fleet at full speed. And lastly, it may be remarked that the employment of ships such as these for keeping up the coal supply of fleets at sea would, to a great degree, make it unnecessary to provide armed convoys, which would have to be done in the case of using ordinary colliers. This would conduce to efficiency, for our sea-going war fleets could be kept up to their full strength, which could not be done if they were required to furnish armed convoys for colliers.

As to the expense of adding to the present number of coaling stations, and efficiently protecting all of them, it must be considered as part of the price we have to pay for national maritime insurance ; and, considering the enormous importance of the interests involved, it would surely be impolitic in the highest degree to allow considerations of mere economy to prevent that which is so clearly necessary, not only for the efficiency, but even the *safety* of sea-going fleets in a time of war, viz., making provision for a coal supply that would enable our ships to keep the sea, and always be on the "weather side" of the enemy.

In discussing this matter it should not be forgotten, or even lost sight of for a moment, that of all the marvellous changes that have taken place in the Navy, there is not one so important, or so far-reaching in its results, as the total abolition of sail power in our modern battleships and large cruisers. The substitution of steam power, on which alone the efficiency of the ships depends, makes it necessary to provide ample means for the maintenance of the coal supply, and an endeavour has been made to show how this might be done so as to make it possible for our fleets and squadrons to keep at sea for an unlimited time.

Coal is to the propelling and other machinery what wind is to the sails, food to the men, ammunition to the guns ; and it is something more, for with but little food, without ammunition, but *with* coal, the ship's efficiency can be restored by proceeding to the nearest station to replenish. With food and ammunition, but *without* coal, modern war-ships are helpless ;

able, perhaps, to offer a feeble resistance to an enemy, but liable to easy capture.

Nothing has been said of the third plan, because the advantages of having some sail power auxiliary to the steam power are obvious, especially for vessels which have to cruise for long distances on foreign stations; and the mere statement of the fourth plan is considered sufficient. Sail power in modern battle-ships and large cruisers appears to be dead ; hence the suggested application of the first and second plans in combination for keeping up the coal supply of sea-going fleets.

Here two questions may be asked : Are the two proposed plans feasible, workable, practicable ? And secondly : Is the object aimed at desirable and necessary? If these questions be answered in the affirmative it would be well to take measures to carry the plans into effect ; in any case the discussion of the subject will be beneficial, for it is very doubtful whether the whole question of coal supply has been sufficiently considered in its bearing on the future of the British Navy.

CHAPTER II.

ON THE ENGINE-ROOM COMPLEMENTS OF HER MAJESTY'S SHIPS.

Quotation from the *Times* announcing a reduction of the number, and lowering of the quality of engine-room complements—Names of ships representing several classes—Verification of statement—Remarks on the increased value, amount, and importance of the steam and other machinery now fitted in ships as compared with former days—How the alteration in complements will affect (1) Efficiency, (2) Economy—Former more important than latter—Two distinct and different kinds of duties performed by the engine-room complements —(1) Examination and repair, (2) Engine-driving—A staff that can do the first can also do the second—The converse not necessarily true—Examples given—The assertion that chief stokers are better managers than junior engine-room artificers considered—Case in illustration—Substitution of a number of chief stokers (skilled labourers) for as many engine-room artificers (qualified mechanics) would cause a small saving in the annual expenditure, but would injuriously affect efficiency—Statement showing how this would be done, and the ultimate pecuniary loss accruing therefrom—The "stitch in time" would not be put in, and the "nine" would have to be put in at great cost by the dockyards—Result of alteration of complements prejudicial to the Naval Service—Reasons for this—Complements should be made stronger instead of weaker—Two reasons for this—Remarks on the skeleton crews of ships in the Fleet Reserves—Are our Steam Reserves strong enough to provide these, and retain enough to carry on the normal work of the Reserves?—The difficulty in furnishing efficient engine-room complements to the large number of ships that would be commissioned in the event of a declaration of war—Reference to parts of this book which bear on this subject—Conclusion.

IN the month of April, 1892, a statement appeared in the *Times* on the subject of this chapter. The statement was as follows:—

"The Admiralty are, at the present time, engaged

in reducing the engine-room complements at the rate of 30 per cent. When commissioned the *Calliope* will be deprived of the services of an assistant engineer, and a similar change will be made in the whole of the cruisers of the *Pallas* class. The engine-room artificers of the *Bellona* and *Barham*, the machinery of which is now in sole charge of a chief engineer, have been reduced from six to three, the difference being made good with chief stokers. In the *Phœbe*. again, the number of engineers borne has been decreased from four to two"—50 per cent—"and the artificers from nine to seven, two chief stokers being added to the complement. A more serious change has been made in the *Royal Sovereign*, on board of which, notwithstanding the number of her engines, the artificers have been reduced from eighteen to twelve."

This statement has been verified by the fact of the reductions and alterations mentioned having been actually carried out in the cases of most of the vessels commissioned since that time.

Now, in view of the very greatly increased *amount*, *value*, and *importance* of the steam and other machinery now fitted in our war-ships, as compared with former days, this reduction of the number and lowering of the quality of the engine-room complements is a most serious step to take, calculated to seriously impair the efficiency, and, paradoxical as it may appear, increase the cost of our sea-going fleets.

As efficiency in all cases is much more important than economy, we will consider first how the altera-

tions in the engine-room complements will probably affect the efficiency of our sea-going fleets.

It has been said that the amount, value, and importance of the steam and other machinery now fitted in our ships of war, as compared with former days, have been greatly increased. As to the *amount:* It is well known that there are scores of steam-engines in our largest ships, and a corresponding number in the smaller vessels. Much of this is called the auxiliary machinery, and it does a great deal of the work of the ships which has hitherto been done by manual labour. Moreover, the duplication of the propelling engines alone doubles the amount of machinery connected with those engines, all of which has to be kept in good condition by the ship's staff.

The *value* of the machinery has been greatly increased by the fitting of the auxiliary machinery, and the duplication of the propelling engines and machinery connected therewith.

The *importance* of the steam machinery is measured by the fact that, in these days of mastless war-ships, the efficiency of a ship depends *wholly* on the engine-room department, and on the ability of the staff of the ship to keep all the machinery in very good condition. Now, this cannot be done unless the engine-room complements are, in respect of number and qualifications, equal to the performance of this important work.

There are two distinct and different kinds of duties which the engine-room complements of modern war-ships have to perform. Of these the more important is—

1. The making of examinations and such timely repairs as may be necessary to keep the machinery in good condition :

And of *considerable*, though of *less* importance ;

2. To keep the watches—that is, to drive the engines to the utmost advantage when cruising or making passages.

Here we may remark that engines cannot be driven to the utmost advantage unless they are in very good condition, therefore the antecedent work of keeping the machinery in good condition, by timely and efficient repair, is of much greater importance than the simple watch-keeping and engine-driving. It is here that uninstructed people make the greatest mistake in considering the requirements as regards engine-room complements : they consider engine-driving to be the only important thing to arrange for, whereas, as we have seen, and as we shall show further by-and-bye, the mere engine-driving is, comparatively, of minor importance.

It is probable, indeed it is certain, that an engine-room complement equal to the repairing of the machinery, and maintaining it in an efficient condition, would also be an excellent watch-keeping engine-driving staff, but the converse of this is not necessarily true : it is possible that a good engine-driving staff might be a very inefficient staff for making repairs. It is well known by those who have any experience in naval engineering that leading stokers very often make excellent drivers of the auxiliary engines, and the engines of steam launches, pinnaces, and cutters; but these men

are nearly always quite incapable of making repairs, and therefore when the day's work of driving is finished, an engine-room artificer, a qualified mechanic, is generally sent to examine the engines, and apply the "stitch in time" that will very soon become "nine" should this be neglected. Thus it will be seen that a good engine-driving staff need not be, and very likely would not be, an efficient staff, for carrying out *all* the important duties required of an engine-room complement of a modern ship of war.

It would appear that the recent readjustment of the engine-room complements have been made on the assumption that the only, or the chief, thing necessary, is the provision of an efficient engine-driving watch-keeping staff; hence we see that chief stokers have been substituted for engine-room artificers—that is, skilled labourers for qualified mechanics. All classes of stokers are labourers; the chief and leading stokers are the skilled labourers, the 1st and 2nd classes of stokers are the ordinary labourers. It is true that the most intelligent and useful of the leading and chief stokers are called stoker-mechanics, and each of these men get threepence per diem for qualifying as stoker-mechanic; but it will be allowed that the mechanic qualification which can only command a pay of *threepence a day* cannot be of a high class, and, in fact, these men, though very useful, and often intelligent in the performance of watch-keeping, engine-driving duties, are, generally speaking, quite unable to take any part in the repairing work, which must be done to keep the machinery in good condition.

But it has been said that chief stokers are better boiler managers when under steam than junior engine-room artificers, and this has been assigned as a reason why the chief stokers have been substituted for junior engine-room artificers, who are necessarily inexperienced in this work. To this it must be answered, that junior engine-room artificers do not long remain inexperienced. Any moderately-intelligent artificer would very soon acquire expertness in the management of steam boilers, and thereafter he would be a much more valuable member of the engine-room staff than the chief stoker, who, it should be remembered, is really nothing more than a skilled labourer. Take a case in illustration of this : A ship commissions for a service of four years, and to her are drafted several chief stokers and junior engine-room artificers. Now, there is nothing extraordinarily difficult in engine-driving or in the management of boilers. Any tolerably sharp young engine-room artificer would in four months, with practice under steam, be quite the equal of the chief stoker as regards the management of boilers when steaming. Therefore, the case may be stated thus : For four months of the four years' commission, the junior engine-room artificer would be inferior to the chief stoker, and for the remaining three years and eight months would be equal to him as regards boiler management, but very much superior to him as a qualified mechanic, fit—as a chief stoker could never be—to be a valuable member of the repairing staff of the ship. In this way may the value of the services of the two men be differentiated, and it shows how much the *quality* of the engine-room

staff will be lowered by the substitution of the lower for the higher class man.

It will, perhaps, be generally admitted that the keeping the machinery in good condition, by timely and efficient repairs, which can be done only by qualified mechanics, is of much greater importance than the mere engine-driving, and therefore it will be seen how seriously the efficiency of the steam department of a war-ship, full of valuable machinery from stem to stern, might be impaired by the substitution of a number of chief stokers (skilled labourers) for as many engine-room artificers (qualified mechanics), and how heavily handicapped the engineer officers of our ships would be in the performance of the most important of their duties. And this will apply to all classes of ships, from the largest to the smallest, in which the alterations in the engine-room complements will doubtless be made.

The question of economy in connection with this subject will be dealt with by-and-bye, but it may be well to state here that there is no doubt that the substitution of chief stokers for engine-room artificers, *i.e.*, men in receipt of a lower rate of pay for others in receipt of a higher rate, will result in a small saving on the annual naval expenditure. But this economy will be dearly purchased, if it results in a serious loss of efficiency. With an inefficient repairing staff no chief engineer could keep his machinery in such good condition as would enable him to drive the engines to the utmost advantage: the horse-power developed would not be that due to the coal that would be consumed. This would affect the coal endurance, and materially

shorten the time a ship could keep the sea; it would cause the detachment of the ship from the service of the fleet oftener, because of the necessity for coaling at shorter intervals. Finally, with the machinery not in good order, it would be impossible to steam a ship at the highest rate of speed.

Thus it will be seen how an inefficient engine-room staff, weak in respect of qualified mechanics, might cause a serious loss of efficiency in the steam department, a department on which the competence of a modern mastless war-ship to perform good and useful service wholly depends.

The recent alteration in the engine-room complements, viz., the substitution of chief stokers for engine-room artificers, also affects economy, for though it will result in a small saving in the annual naval expenditure, for the reason assigned in a preceding paragraph, it is possible, and even probable, that its result will be an ultimate loss. For if, in consequence of the weakness of the mechanic, *i.e.*, the repairing staff, the machinery cannot be kept in that good condition which will ensure the engines being driven to the utmost advantage, it will result, as has already been shown, in a much greater expenditure of coal and other stores, entailing a great pecuniary loss.

But this is not all: because of the weakness of the repairing staff, the "stitch in time" will not be applied during the ship's service at sea, and the "nine stitches" which might otherwise have been saved, will have to be put in when the ship reaches a dockyard, when we may expect, in nearly all cases, long lists of defects to be

sent in, which will have to be made good by the dockyards at a very great cost. So that to measure the pecuniary loss caused by a weak engine-room complement we must take into account—

1. The increased cost of the sea service of the ship, caused by the machinery not being in the necessary good condition.
2. The cost of repairs by dockyards, which might have been prevented had there been a sufficiently strong staff on board to maintain efficiency.

This would amount to a large sum, and the only set-off to it will be the saving represented by the difference between the pay of the engine-room artificers and the chief stokers substituted for them.

So much for Economy, which will not be further dwelt on here, because it is considered that, as compared with Efficiency, mere economy is an unimportant element in the discussion of this subject.

It is scarcely necessary to say that, for the reasons set forth in the foregoing remarks, it is considered that the alterations lately made in the engine-room complements, by reducing the number of engineer officers, and substituting chief stokers, for about thirty per cent. of the engine-room artificers, are calculated to seriously impair the efficiency of our sea-going fleets. In considering this, it is necessary to keep in view, and give special prominence to, one fact which cannot be disputed, viz., that in these days of mastless war-ships the efficiency of sea-going fleets depends *wholly* on the engine-room departments of the ships—that is to say, on

the machinery being kept in good condition, and, of necessity, on the engine-room complements being, in number and qualifications, equal to the work of maintaining the machinery in that good condition.

Instead of weakening engine-room complements I advocate strengthening them, and for two reasons :—

1. To make sea-going fleets self-supporting; able in all respects to maintain the efficiency of the machinery without outside assistance.

There can be no reason whatever why, in a well-fitted ship, with a *sufficiently strong engine-room complement,* the efficiency of the machinery should not be maintained from the beginning to the end of the commission by the fleet men, without any assistance from dockyards.*

2. In order that, in case of war being declared, a fractional part of these strong engine-room complements might be available for service in the numerous ships that would certainly be commissioned at such a time. The officers and men so transferred would form a nucleus for the complements of the newly-commissioned ships, and in both cases the complements might be completed by drafts from the Royal Naval Reserves.

This seems to deserve some consideration; it is evident nothing of the kind can be done now; no further depletion of the already-weakened complements can be

* *Vide* "Naval Engineering," Chap. III.

carried out without serious injury to the steam service of the ships.

I am aware that to this it may be answered that there is already provided a nucleus for the engine-room complements of all ships in the advanced class of the Steam Reserves; that skeleton crews are provided for these ships; but it is certain that the small number of ships in this class would not suffice for the country's wants in case of war being declared; also that there are, as a general rule, so small a number of available officers and men in the Steam Reserves that it is found at times to be barely possible to provide the skeleton crews, and at the same time reserve a number of fleet mechanics sufficient to carry on the normal work of the Reserves, in the care and preservation of the machinery of the ships in charge of the Steam Reserve staff. If this be so, if our Reserves are weak in respect of fleet mechanics in a time of peace, what would be our condition if war were suddenly declared? How would efficient engine-room complements be furnished to the large number of ships that would undoubtedly be commissioned? In this connection the second reason, given on the preceding page, why strong complements should, on commissioning, be drafted to all sea-going ships of war, is commended to serious consideration. Also the part of this book,* which discusses the best way of strengthening the Steam Reserves, and which gives other, and, it is submitted, very cogent reasons why this should be carried out.

It should be, and no doubt is, the wish of everyone

* *Vide* Part III. "Naval Engineering," Chap. IV.

proud of our Navy, and of its achievements in the past, to maintain its efficiency in the highest possible degree, and therefore, in view of the absolute dependence of our mastless floating batteries on the steam service of the ships, it may be hoped that the authorities will decide that it will be for the best interests of the Navy that strong engine-room complements shall, on commissioning, be drafted to all sea-going war-ships.

CHAPTER III.

REMARKS ON ELECTRIC LIGHTING AND OTHER SUBJECTS.

Reference to drawbacks connected with useful and beneficial inventions —Electric lighting of our ships—Necessity for the fitting another system, to be used in case of the failure of the dynamos—Illustrated by a case which actually occurred in a French war-ship—Discussion of the subject by the members of the Royal United Service Institution—Speech of Admiral His Royal Highness the Duke of Edinburgh, the chairman of the meeting—Remarks on steam steering machinery, and all machinery connected with double distillation, air compression, mooring and unmooring ships—Remarks on the question whether it is necessary or expedient that engineer officers should be made executive officers—How would the change affect the good order and discipline on board a commissioned ship of war?—Result of discussion: It is neither necessary nor expedient that the change should be made—Reference in conclusion to the experience of the writer.

IT will be useful to make a few remarks on some points arising out of, but not directly connected with, the subject-matter of the foregoing chapters of this book.

It has been said that any new invention or system should be most severely tried in every way, especially by the experimental test, before its adoption in such a great and important Service as the Navy. Probably there will be few who will contest this, and therefore it is not necessary to advance any argument in its favour. There are drawbacks connected with the most useful and beneficial inventions. Take electricity:

There is no doubt that the greatest benefit has been derived from the various applications of electricity. But even here it is well to proceed with caution. An illustration of this occurred a few months ago. One of our talented officers read a paper* on this subject before the Royal United Service Institution, and a discussion followed. His Royal Highness the Duke of Edinburgh was in the chair, and the lecturer, Captain Eardley Wilmot, R.N., and His Royal Highness all declared themselves to be of opinion that there was danger in adopting electricity to the exclusion of any alternative system. All agreed that the ordinary plan of lighting a ship, for instance, should be fitted side by side with the electric light, so that if this failed the other could be readily put in operation.

The practical wisdom of this idea was verified, only a few weeks after, by a serious boiler explosion that occurred on board a large French war-ship† during a full-power trial, in the course of which, by the failure of the electric light in the stokeholds, they were plunged in darkness. In the confusion that was caused by this the water ran low in one of the boilers, and it exploded with serious results. In His Royal Highness's (the chairman's) summing-up speech, he said :—

"I cannot help thinking that if we are to trust entirely to . . everything being worked by electricity in a ship, in time of action, we shall stand at a great deal of risk." The accuracy of this forecast was verified

* Read by Lieut. F. T. Hamilton, R.N., 4th May, 1892. See *Journal of the Royal United Service Institution*, June, 1892.

† Full-power trial of the *Dupuy de Lôme*, June 20th, 1892.

in a remarkable way by what occurred six weeks afterwards in the French war-ship.

As with electric lighting, so also with steam steering. The steam steering machinery now fitted in ships is of a very perfect character, and it seems to be nearly impossible for it to fail; but there *is* this possibility of failure. It is a very small thing that will cause the failure of any machinery. A linch-pin in a carriage is a small and insignificant thing in itself, but if it comes out the carriage breaks down by the disconnection of the wheels, and serious injury or even death to those in the carriage might be the result. In like manner the disconnection of a small pin or bolt may cause in a moment the failure of the steam steering-gear, and therefore there is now, and it may be hoped always will be, fitted the hand-steering machinery to revert to in case of necessity.

Also, as to the propelling engines of a war-ship: They are started, stopped, reversed, worked in every way by small steam engines, which by breakage or in some other way may fail at any moment to act. Therefore there is machinery fitted whereby the working of the engines might be done by "hand-starting gear." In every case, however perfect the fitting, the machinery of which modern ships are full, is more or less liable to failure; more with careless, and less with careful management. An undeveloped and unseen fracture of a shaft may after a time cause the breakage of the shaft, and make it impossible to work the engine of which it is a part. Here the duplication of the propelling machinery is of immense advantage, for it is scarcely

possible that both sets of engines can become defective *at the same time:* each set works in every way independently of the other, and thus there will be always one set of propelling machinery, efficient, with which alone a ship can be steamed at three-fourths of the full speed attainable with both sets. There is no doubt that in every case, when it can be easily done, the duplication of all parts vital to the efficient service of the ship should be carried out. It is so with the lighting, steering, and propelling of all war-ships, and it would be well to act on the same principle, when possible, as regards the machinery for double distillation, air compressing, mooring and unmooring ships, and all other arrangements in which the failure of a single set might cause a serious loss of efficiency.

It may be well to make a few remarks on another subject. Some engineer officers advocate that all the members of the class should be made executive officers. From the engineer officers' point of view it is probable that this would be unobjectionable, but it is doubtful whether the change would in the end benefit either the class or the Navy at large. There is much sentimental talk indulged in on this subject, such as, *e.g.*, that civil officers, having no executive authority, cannot legally maintain the discipline of any department of which they have charge; also that the youngest midshipman can give an order to the most senior fleet engineer, which the latter would be bound to obey; and such like. Now anyone with practical experience in the Navy must know that there is no force in these arguments, and that any grievances on these grounds

are non-existent. It is absolutely necessary that the senior executive officer should be in supreme command. Anything in the nature of a divided command cannot but result in confusion, and would seriously impair the good order and discipline which should obtain in every commissioned ship of war. The conferring of executive rank implies the exercise of executive functions, including command; and this, in the case of the engineer class, is of course neither expedient nor necessary. It is not called for in any way. No engineer officer of sound judgment and practical experience—which all must get while passing through the junior ranks—can find the least difficulty, as a non-executive, in maintaining the good order and discipline of his department. The authority delegated to him by the Captain will at all times be sufficient for this, and Captains of modern war-ships, in view of the dependence of the ships on the steam department for successful service, will most assuredly support their departmental officers in everything that contributes to the efficiency of their ships. Therefore any supposed grievances which are caused by the engineers not being executive officers are in the highest degree unreal and indeed sentimental. These officers have their hands full in attending to the efficient administration of their departments, and need not concern themselves in trying to get executive rank, from which, if conferred, it is very doubtful that they, as a class, would derive the least benefit, and which it is still less likely would benefit the Naval Service. These opinions of a non-executive officer are based on an experience gained during nearly forty years' active service, during

which no difficulty of any kind in carrying out his duties, as regards the maintenance of the discipline of his department, has at any time been met with ; and it should be noted here that he has had sole charge of the steam departments of the ships in which he has served since he was twenty-four years of age.

THE consideration of subjects concerning the Steam Navy of England has been presented in several divisions, each with its sub-divisions; but the general parts, though separate for the sake of convenience, are yet inseparably linked together in the consideration of the Navy as a whole.

A war-ship is made up of a great number and variety of parts; and similarly, its *personnel* consists of officers and men of several classes, ranks, and ratings. Now the perfect ship of war is that in which each and every part is up to an equally high degree of efficiency; and its effective service depends on the competence of the departmental complements to utilise and develop all its power as an engine of war.

Therefore it should be the chief aim to preserve, both in the ship and its *personnel*, that balance of strength and efficiency which will prevent any part of the ship, or any one of its departments, being more vulnerable, or less efficient, than others.

As with single ships, so also with fleets and squadrons, and indeed the principle applies to the whole Steam Navy, which cannot be expected to work well as a whole unless its component parts are so balanced, in respect of strength and efficiency, as to prevent the failure of one or more of the parts.

An endeavour has been made in the following Summary to show how the various parts into which the Navy is divided are linked together, and depend each one on the others; to simplify technical points, adding such remarks as may be necessary to complete the argument; but above all, to show up the weakness of any vital parts (the weak links in the chain), with a view to the strengthening of those parts, and so attaining that perfect balance of strength and efficiency which, it is contended, is absolutely essential to the effective service of our present and future Steam Navy.

SUMMARY.

IN summarising the contents of this book it will be necessary to enumerate, in the order in which they appear, the several points raised and discussed, special attention being given to those, the consideration of which has for its object the ascertaining whether it would be for the benefit of the Naval Service to partially or wholly abandon old systems, and adopt others which commend themselves to us, as more fitted to promote the efficiency of our modern reconstructed Navy. And, as has been already remarked, in order that each question should be decided on its *merits*, it would be well, so far as possible, to dismiss from our minds all undue bias, whether in favour of new schemes or against what many consider obsolete systems—that kind of prejudice which, while it is quite unreasonable, appears in many cases to be insurmountable; for it often blocks the way of salutary reforms, and prevents rational progress. Its argument is twofold. It is not only that what has lasted a long time *must* be right, but also, what has lasted a long time, right or wrong, must be intended to continue. This springs from a strong element in human nature, a reverence for existing usages; a natural conservatism, combined with a fear

that any change is simply taking a leap in the dark, the results of which cannot be foreseen. The exercise of this natural conservatism operates beneficially when it induces a thoughtful deliberation and full discussion of any plan the adoption of which would cause any great change in existing usage. It compels a threshing out of the matter, which places before us everything that can be said either for or against it, and prevents a too hasty adoption of any scheme which would be prejudicial to the Service and the country at large. But when, by the exercise of an extreme form of prejudice, it bars all rational advancement, and by preventing salutary change tending to improvement, causes stagnation, it is a "stone wall" which cannot be surmounted: the conditions may change, but the old system must go on for ever. "What has lasted a long time, right or wrong, must be intended to continue." With these remarks we will proceed with a categorical enumeration of the points which have been presented for consideration in this book.

I.

Our Seamen.
The Fighting Power in Ships of War.
Page 3.

THERE are in our Navy several thousands of non-combatants, men who contribute nothing to the skilled fighting power of our fleets. These men, for reasons stated, have for several years past been increasing in number, until at present they form from 27 to over 40 per cent. of the crews of our ships of war. Is it desirable that our war-ships should go to sea with so large a proportion of the crews

non-combatants? If the answer be Yes, there is an end of the matter; we will maintain things as they are, and hope all will be well.

If, however, it be No, then the further question arises, Can the large majority of these non-fighting men be trained into combatants?

There is a class of men, the stoker class, in the Navy, numbering perhaps at present 12,000, and these men of the different ratings in this class form about 70 per cent. of the whole number of non-combatants in the Navy. It is asserted that these men can be trained into skilled gunners, and a definite and elaborate scheme in detail is submitted, by which it is contended this very considerable increase in the fighting power of the Navy can be carried into effect. Moreover, by this scheme, this training of 12,000 stokers into gunners can be effected without lessening the skill of the men as to their special duties as stokers, with no expense in respect of an instructional staff, with no addition to the aggregate number of men now in the Navy, and with no interruption in the general routine carried out in commissioned ships. Lastly, *providing that the scheme be carried out in its entirety in all its details*, it will be automatic in its action, and, supposing it to be in operation a sufficient time to have its full effect, will result in an enormous increase in the fighting power of the Navy, by greatly reducing the number of non-combatant men now carried in all war-ships.

For remarks in detail on the suggested scheme, the reader is referred to Part I., Chapter I., but a few additional remarks seem to be called for. By the pro-

posed scheme, every man of the stoker class in the engine-room complement of every ship, would serve one month in four on deck, performing deck duties, including training in gunnery, and three months in four in the engine-room, so that they should suffer no loss of skill as stokers.

Now this occasional service on deck would be most beneficial as regards the health and stamina of the men. Modern war-ships are altogether unlike those of former days, and one respect in which the changes affect the stoker class is that their work is now very much more trying and exhausting than formerly. When steaming, the stokeholds, generally very small, are closed and made air-tight, air being forced into them by necessary machinery. The men have to work on watch under steam in these confined spaces; the work is very hard and exhausting, and sometimes the heat is excessive. Now the month's service on deck would be of the greatest benefit to these men; their health would be recruited, and at the month's end they would commence their three months' work in the engine-room department with renewed strength and vigour. More will be said on this matter when considering the subject of the next chapter. Meanwhile a reference to the first chapter of the part of this book, entitled "Our Seamen," will place the reader in possession of the arguments, for and against, the adoption of the scheme submitted for the training of a great majority of the non-combatants in the Navy into skilled gunners.

II.

Our Seamen.
General War Training of the Navy.
Page 21.

In this chapter the subject-matter of the first chapter has been expanded. That chapter was devoted to the consideration of the training of a single class, viz., the stoker class, in combatant duties, so that they might be able to perform efficiently all-round duties; to be gunners as well as stokers, deck men as well as engine-room men. In this chapter is considered the larger question, Whether all seamen could not be trained into all-round men; whether, to state the case conversely to the stoker's case, the seamen could not be trained to be stokers as well as gunners, engine-room men as well deck men? In the consideration of this important question it is necessary to note the very great changes that have been made in our ships of war in respect of material, build, rig, tonnage, armament, and engine-power; and the question arises, Do not these changes call for a corresponding change in the training of our seamen to make them fit in with the altered conditions?

Here, as in the note on the first chapter, it must be asked: Is it desirable and necessary that, for the reasons stated, there should be a change in the system of training our seamen? If not, there is an end of the matter, and we must be satisfied with making the best of the present system. If it be considered that some change *is* wanted, then the further question arises, What should this change be? By a reference to the second chapter, on "Our Seamen," it will be seen that the assumption is

that the change wanted is the fusion of the two classes of stokers and seamen, so as to train them into all-round men, competent alike to work on deck, in boats, and between decks; or below, in the engine-room and stokeholds.

Again, suppose it to be decided that this fusion of the two classes is desirable, and should be attempted, then we have another question presenting itself, one by no means easy to answer, viz., How can this be done? Here again, as in the last chapter, a definite plan is formulated, by the operation of which this great work of the fusion of the classes and the training of all into all-round men might be carried out. The plan in detail is presented in the second chapter of "Our Seamen," but the principal parts of the plan may be repeated here. Both classes, seamen and stokers, to be entered as boys, and trained from the first day in the details of ***modern*** seamanship, comprising general deck duties, including gunnery; and engine-room duties, including stoking; to be trained for a time in a stationary modern war-ship, and afterwards in a sea-going ship of the same kind. Boys to be entered at the age of fifteen, and the training to be finished at the age of eighteen or nineteen, when they should be competent to serve in commissioned ships as part complement. During subsequent service they would by experience become more competent, some developing greater excellence as gunners and some as stokers. When rated petty officers men to be kept serving in that department in which they have shown special excellence.

Now, before a decision can be arrived at as to whether

this is a sound proposition or not, we must consider what are the requirements of modern seamanship. In our modern war-ships we have abolished masts and sails, or rather, as one of our Admirals wittily observed, "They have abolished themselves." There are no longer any duties to perform in a modern war-ship appertaining to the *old seamanship*. Then why take up a great part of the boys' student time, viz., from fifteen to eighteen years of age, of the greatest value to the future seamen, in teaching them expertness in the working of masts and sails, and thereafter, for perhaps twenty years, send them to serve in ships in which nothing of the kind will ever be done? The advocates of the present system say it gives a man energy, activity, develops muscular strength; there is some mysterious, occult "teaching power" in sail drill which nothing else can give. There is something transcendental in this view. It does not commend itself to practical men, who consider, with more or less anxiety, the probable wants of our future Navy. Is there no other way in which our future seamen can be exercised in activity, energy, daring? There are large fields opening out for them in the exercise of these admirable qualities, as was well pointed out by Captain FitzGerald, R.N.* But the matter may be further considered from another point of view. In the days of the old seamanship, when sailing was the chief element in the propulsion of our ships, and steam was yet only an adjunct, a boy was very properly taught during his training time to be active, energetic, and daring in exercise aloft, and after

* *United Service Magazine*, April, 1891.

his three years of training, he was drafted to ships, and served for the whole of his active career in ships in which this exercise aloft was absolutely necessary for the active service of the ships. The skill acquired during the three years of training was utilised during the twenty or thirty years he served as a seaman. Therefore no training system could have been more admirable, and more calculated to effect the purpose for which it was wanted, than the old system. But is this so now? Will it meet the requirements of modern seamanship? Are our seamen required to exercise aloft? Will their activity, energy, daring, and courage, which they have exercised during their boys' training time be further exercised and developed in the same way by their service as men in modern war-ships?

The whole subject is threshed out in the third and fourth chapters of the first part of this book, and readers are referred to them, in which will be found quoted the opinions of many naval officers of the highest rank, distinction, and experience; opinions which should have great weight, as those of men with a full knowledge of the subject looked at from every point of view, but especially from the point of view of professional naval experts, who are necessarily much better informed than any laymen can be.

It will be well to make a few further remarks on a part of the subject already referred to in the note on the first chapter. It is perhaps a part of minor importance, a matter of detail, which nevertheless many people might consider one of the good results arising out of the plan for training both seamen and stokers into

"all-round" men. It has been stated that the work of the stoker is, in these days, of a very trying and exhausting character. If seamen, as well as stokers, were trained as "all-round" men they would be able to stoke the fires when wanted, and the work, the exhausting work, of steaming a vessel a voyage of several thousand miles, might be distributed among the whole of the ship's crew. Thus, while on passage, each man would be employed part of the time below in the stokeholds, and part of the time on deck, during which he would recruit his strength, and be prepared to take again his spell at engine-room work. I read a description a short time ago of a voyage of one of our small war cruisers, a third-class cruiser. The voyage was one of several thousand miles, and the whole of it was of course done under steam, a great part of it in the tropics. The heat on deck was at times excessive; in the stokeholds it was stifling. Now, there was no sailing to do, therefore the seamen, after doing the work of keeping the ship in order, and going through their drills, had nothing to do except to sit down on deck, keep themselves as cóol and comfortable as possible, and let the steam-power drive them along. Not so the stokers; they had the whole of the stoking work to do, and very exhausting work in the tropics it must have been, causing among the weaker men frequent visits to the doctor, and an occasional stay in the sick list. As the story goes, when the ship arrived in port there was a great deal of work to do in connection with coaling, and the refitment of the ship's machinery for further service, and during a great part of the time,

while these already over-worked stokers were doing the work, the seamen, who had led such an easy life on deck while on passage, were allowed on shore on leave to walk about and enjoy themselves. Now, if all men were trained into "all-round" men, to do stoking as well as deck work, the exhausting work of steaming a ship while on passage might be shared by the whole of the crew, to the great advantage of the stokers, without any detriment to the seamen, and with a very beneficial result as regards the general health of the whole crew. This is one of the benefits, and, from the medical officer's point of view, not by any means a small one, that would accrue from the adoption of the system of training all men as general service men, to be interchangeable, able to work either on deck or below, as found necessary. Here may be usefully quoted a paragraph, which bears on this subject: "The duties of the seamen of the *past* were performed on deck and *aloft*. Those of the seamen of the *future* will be performed on deck and *below*." It is obvious, therefore, that our seamen should be trained to perform with intelligence and skill the "*on deck and below*" duties, which will constitute the seamanship of the future.

III.

Our Seamen.
The Training of.
Page 33.

THIS chapter refers to the discussion of the general subject from the commencement up to the present time; and the expressed opinions of many able officers are quoted at some length. Its object is to show the general drift of the discussion, as, *e.g.*, whether the

balance of the opinions of experts is in favour of changing, or of retaining, the present system. Generally speaking, it is the continuation of the consideration of the whole subject, carried on from the two previous chapters. The end aimed at is to ascertain whether our present training system is calculated to fully meet the wants of modern seamanship, and, if not, what should be substituted for this system. Two definite plans have been submitted to public notice and criticism, viz., that of Sir Edmund R. Fremantle, and that contained in the second chapter of this book, which, it is contended, is really the only plan in detail for training all our boys into general service men.

IV.

Our Seamen.
The Training of
(*continued*).
Page 47.

THIS chapter is devoted to summarising the contents of the three previous chapters, and, carrying the discussion still further; the question of expense is considered in connection with our gunnery establishments, and the training of 12,000 men of the stoker class in gunnery, as proposed by the plan in the first chapter. The wants of the Navy as primarily a War Service are considered as regards the *personnel.* Of the seventy new war-ships shortly to be completed and added to the Navy, how many will be masted ships, built to make passages under sail? Is it in contemplation to build any such ships? Will not competent men be required to serve in mastless war-ships? These questions are considered, and also the necessity of a training that will develop muscularity, activity, energy, and

daring. The chapter ends with a quotation from the published speeches of a Vice-Admiral, and an Admiral of the Fleet.

It may be added, that only recently a naval officer of high rank and great distinction, who has an experience in the Navy equal to that of any now serving, has recently expressed an opinion which should have an influence on future administrators of the Navy. Admiral Sir A. H. Hoskins, in July last, distributed the prizes to the most successful cadets on board the *Britannia*, at Dartmouth, and in the excellent speech he made to them he spoke as follows:—

"With reference to a knowledge of steam, it was apparent that such a knowledge was a great necessity in the Service. The sails, which used to be their motive power, were *now things of the past*, and it was exceedingly important that their young officers should have a full knowledge of their new motive power."

Now, Admiral Hoskins is credited, rightly or wrongly, with holding conservative views as to naval administration generally, and it is unlikely, indeed it would seem impossible, for him to consent to the adoption of any great change in our naval system, unless it were clearly proved that it would be for the benefit of the Service. Therefore the expression of the opinion quoted is a remarkable recognition by him of the fact, that the "old seamanship has passed away," and, as a logical consequence, that it is necessary for the training of our officers and men to be such as to fit them for the performance of all the duties pertaining to the modern seamanship, which has taken the place of that old sea-

manship. I can look back to a time when nearly all our war-ships were sailing ships, and to another time when sail and steam power were combined in such a way that the ships were also, when not using steam, fully ship-rigged sailing ships. It has often raised my admiration to see the manner in which my ships have been sailed, sometimes under very adverse circumstances, by the officers and men, who were such excellent experts in the science of the old seamanship. I recollect one of many instances of the kind. Standing on the poop of a large ship-rigged vessel, I saw her worked with the same ease and dexterity with which a small child could manage a toy, and this though there was a moderately heavy sea running, and a very fresh breeze. The Captain, who was, in the opinion of the officers competent to judge, a most excellent seaman, both theoretically and practically, and also a most genial man, was standing on the poop, and incessantly putting up his eyeglass to minutely scan every rope and the set of every sail. The ship was beating dead to windward, and between the times of tacking there was a pause, when the men at the wheel seemed to be the only ones doing anything. During one of these pauses I observed to the Captain that, to me, this was a beautiful sight, especially as the whole operation was simply one of practical mechanics. He replied, "It is, Williams, neither more nor less than the application of some of the theories of mechanics." And again he raised his glass and looked aloft, where every rope was as rigid as if it were wire, and every sail was drawing as perfectly as possible. I saw his eyes sparkle, and

his face showed intense pleasure, a feeling almost of exultation, as we felt the ship plunging and cleaving through the water like a thing of life, but subject in every minute particular to the controlling power.

Who can wonder that the abolition of this old seamanship is "unpalatable?" There is a kind of pathos in the expression of opinion of Admiral Commerell, so experienced and so able an officer, in the exercise of the old seamanship. "It may be an unpalatable fact to a great many of us: *it is a* VERY *unpalatable one to me,* and that fact is, that as masts and sails have passed away, the training of the men in that line who worked them will have to pass away too."

We may be sure that nothing but an absolute conviction of the necessity of change, would ever have drawn forth such an expression of opinion from one, who must be credited with an ardent love for the old seamanship.

V.

Ships and Machinery.
Forced Draught in Boilers of War-ships.
Page 61.

In this chapter are considered the great changes made for several years past in Her Majesty's war-ships; the abolition of masts and sails in modern battle-ships and cruisers; increased weight of armament and ammunition; the heavy protective plating; great amount of auxiliary steam machinery; the duplication of propelling engines; the necessity for a great coal-carrying capacity; the alteration in the design of propelling engines from simple to compound and from compound to triple expansion; the

necessity for using steam of a very high pressure, and the manufacture of boilers strong enough to be capable of safely bearing the greater strain due to the higher pressure. Forced draught was introduced in order to obviate the necessity for carrying heavy boilers, which would be necessary if a purely natural draught were used. A full description of forced draught is given, and its action on the boilers, when in operation. Definitions are given of an excessive and unsafe forced draught, and also of a limited forced draught, the use of which is both safe and beneficial. A reference is made to the very numerous cases of the breakdown of new boilers on full-power trials, caused by the use of the excessive forced draught. Illustrations are given as to the results, in respect of speed of ships, and the development of engine-power obtained by the use of (1) the excessive and unsafe forced draught, (2) the limited and safe forced draught. There are no instances on record of the failure of new boilers by the use of a purely natural draught. A full description and explanation is given as to (1) the nature of the injury done by the use of excessive forced draught, (2) how this injury is caused, and the subject is fully discussed in detail. The question is answered as to what should be done with the large number of ships in which the excessive forced draught must be used to get the maximum contract engine-power for which the boilers were designed? and also the further question, what measures should be adopted in future ships to ensure that the maximum power and speed should be obtained under *safe* conditions as regards the boilers? Also to the question,

What constitutes an ideally perfect ship of war? There are four great divisions into which a war-ship may be divided—Hull—Armament—Engines—Boilers. Each one of these should be up to an equally high point of efficiency. At the time this chapter was first published* the boilers were the weak link in the chain. An opinion is expressed that before boilers can be worked safely under forced draught, with a high air pressure, material alterations will have to be made in the designs. What this alteration should be will be explained in succeeding chapters. Meanwhile we must not be unduly influenced by the action of other nations, in adopting, without sufficient trial, new inventions; but should endeavour to lead others in the building and equipping of perfect ships of war.

VI.

Ships and Machinery.
Induced Draught *v.* Forced Draught in Boilers.
Page 80.

THE subject of Induced Draught as compared with Forced Draught is considered in this chapter, with a view to discovering whether the inventor's claim as to its usefulness will probably be realised. After a brief reference to forced draught, a full description of induced draught is given, and the way in which it operates in the rapid generation of steam. This investigation results in this: that the principle which governs the action of both forced and induced draught is the same, and that therefore there is no reason to expect that the application of induced draught,

* It was first published as an article in the *Illustrated Naval and Military Magazine*, July, 1890.

if pushed beyond a certain limit, would be more successful than forced draught. Reasons for this are given in full, and at considerable length. As with all other inventions, so also with this induced draught; it deserves a fair trial by actual experiment, under the same conditions and circumstances as the forced draught. These conditions are fully defined with a view to the trial being conducted with strict impartiality, and to prevent the too hasty adoption of the invention on insufficient trial, which it appears was done with forced draught.

Two suggestions are made as to the governing principle of the design of future boilers, and the chapter finishes by remarking that the failure of boilers to come up to the requirements is caused by too much attention being paid to the fireside, or outside of the boilers, and too little to the waterside, or inside of the boilers.

The chapter on Induced Draught, like that on Forced Draught, appeared first* as an article in one of the leading Service journals more than two years ago, and some further remarks are necessary, which will be found in the next chapter. Meanwhile, as regards induced draught, there does not appear to have been any exhaustive trial by actual experiment up to the present time, such as that suggested in this chapter. But it is understood that Mr. Martin, the inventor, has received permission to fit his apparatus to the boilers of a vessel at Sheerness, of the *Sharpshooter* class, and no better vessel could be selected for the purpose, for it is in this class of vessel that forced draught has resulted

* *Illustrated Naval and Military Magazine*, Oct., 1890.

in every case in failure to get the full contract engine-power, viz., 4,500 H.-P., for which they were designed. Even in the *Gossamer* and *Gleaner*, which are improvements on the former vessels of the same class, no more than 3,800 H.-P. has been obtained. It may be said at once that if in one of this class of ships, by the use of the induced draught, 4,500 horse-power can be developed without any injury to the boilers, it may be considered a great success. But the trials must be of sufficient length to determine whether it will ensure the *continuous* efficiency of the boilers, as will be fully explained in the next chapter.

There is also another very important condition which must be laid down. Induced draught must, to test its merits, be tried by *itself alone*; there must be no other scheme tried in combination with it; such, for instance, as the ferruling of the fire-box end of the tubes by the lately invented ferrule. This would be manifestly unfair, for no one would know how much of the success would be due to the induced draught, and how much to the ferrules. For reasons given in the next chapter, it is considered that these ferrules *could of themselves* enable boilers to go through, with more or less success, a pretty long forced draught trial, with the use of a higher air pressure than could otherwise be used. These ferrules would, however, it is considered, not be efficient for any length of time, because they are thin where they are exposed to the action of the flame, and at this very part are unprotected by the contact with the tube and the water in the boiler. The ferrule ends would therefore probably burn away rapidly and drop off. But, as has

been said, there is no doubt that, by the use of this ferrule, a set of boilers will get with some success through a forced draught trial, which could not otherwise be done. It will be seen at once, and clearly, that if these ferrules be tried in combination with induced draught it will not settle the question whether it is able to do with safety what forced draught cannot do; therefore the settlement of the question of Induced *versus* Forced Draught will not be obtained unless the induced draught be tried *alone*, on its own merits. A careful reading of the chapter on this subject is suggested; it will there be seen that I cannot agree, that theoretically, there is any difference between the two draughts—induced and forced—as to the underlying principle which governs the action in both cases. We are therefore compelled to fall back on what, after all, is the very best test, viz., the experimental test, which alone can decide any matter of this kind, on which opposite views are held by professional men.

VII.

Ships and Machinery. Further Remarks on Boilers of War-ships. Page 88.

As more than two years have passed since the two preceding chapters were first published, many changes in respect of boiler design have been made, many of which are in the direction recommended in the chapter on Forced Draught. But some boilers are still faulty in design, as, *e.g.*, the boilers of the *Blake*, *Thunderer*, *Vulcan*, and some others; so much so, that the limited air pressure used safely in other types of boilers, cannot be used in the ships named.

The object of this chapter is to insist on the absolute necessity of imposing such a limitation on the highest actual working strain, as will cause a very considerable difference between the *highest actual working strain*, and, *the breaking-down strain*. A reference is made to cases in which there could have been little or no difference between these two strains, and hence, during the whole of the full-power trial under forced draught, the breaking down of the boilers was imminent. On a trial of this kind, when boilers commence to leak under a certain strain, with the continuance of this strain the leakage never diminishes, but always increases, and prevents, for reasons which will be given at the end of this note, that rapid generation of steam necessary for the development of the maximum engine-power. Reasons are given at length in this chapter as to why the longer boilers remain in use, the less capable are they of being safely worked under forced draught; therefore a safe limit of air pressure should be imposed in view of the actual condition of the boilers.

The principles on which should be based the designs of new boilers, which are intended to be worked under forced draught, with high air pressures, are laid down and discussed in this chapter. Three special points are named as absolutely necessary to be taken into account. Up to the present time these points have not received sufficient attention, and hence the very numerous mishaps to boilers that have occurred, and also the fact, that we have, in many of our ships, boilers that cannot safely do all that they were designed to do.

In this chapter it is contended that the inside, or the water side, of the boilers should be improved in design, for reasons which are given, in preference to resorting to a number of cobbling expedients applied to the fire side, or outside, of the boilers. This is discussed at some length, and reasons are given for opinions expressed.

The chapter ends with a recommendation, that before a new type of boiler is accepted for general adoption, one set should be tested completely up to the breaking-down limit, so as to ascertain the danger point, and that well within this point should be fixed the limit of working strain, which should, on no account, ever be exceeded. The results of the adoption of this plan are given in detail, together with its probable effect on naval efficiency.

It may be well to add a few remarks here, for the information of non-professional people, in explanation of the fact, that directly leakage of boilers commences because of the use of forced draught, the steam-generating power is affected, and it is henceforth impossible to develop the full engine-power until the boilers are repaired by the tubes being made tight in the plates. This sudden fall in the engine-power, which would be most serious in a time of war, or when performing any special fleet service, is caused mainly by three things.

1. By the loss, through leakage, of water at a high temperature, and the necessity of pumping water, at a comparatively low temperature, into the boilers to supply this waste.
2. By the damping effect the leakage has on the fire-box tube plates and combustion chambers,

which causes the retarding of the air draught through the boilers.

3. In many types of boilers the water leaking past the ends of the tubes being spouted into the furnaces, and very considerably damping the fires already dulled.

As, therefore, in the case of the leakage of boilers caused by the use of an excessive forced draught, the effect in the development of engine-power is both great and immediate, it will be seen how disastrous it might be in the case of a war-ship in action with the enemy, and how necessary it is to fix such a limit of strain in boilers, as shall make it certain that they would be worked, at all times, under absolutely safe conditions.

VIII.

Ships and Machinery.
Modern Marine Engines.
Page 111.

In this chapter remarks are made on the changes brought about by the adoption of the triple expansion type of engines, and especially its effect on the coal endurance of war-ships. A full description of triple expansion is given, showing why its use causes great economy in coal consumption as compared with the common type of engines. Also surface condensation of the steam conduces to this end. This is fully explained. The pressure of steam continually falls as it passes through the cylinders by expansion into the larger spaces. A full description is given of the plan by which the engine-power is equally distributed among the three cylinders of a set of triple expansion engines, so as to produce an equality of strain along

the crank shaft. This balance is not always preserved, but varies as described, and for the reasons given in the chapter. And the means of preserving this balance up to certain limits is described; also why, below these limits, this balance is lost. Having enumerated the advantages accruing from the adoption of the triple expansion type of engines, several drawbacks are remarked on; and, as it will be seen by a reference to the chapter, these drawbacks are serious, both as regards the boilers and engines. As to the boilers: These drawbacks have been considered in former chapters; but additional remarks are made in illustration of the points raised for discussion. As to the engines: It is shown that at low rates of speed, the larger, the low pressure engine, is either doing nothing, or is actually being pulled round by the other two. A case is selected in illustration of this—a tabulated result of trials as to engine-power and speed of ships in the case of one of our largest cruisers of the *Edgar* class. This shows clearly that when steaming at an ordinary passage or fleet evolution speed, *i.e.*, from seven to twelve knots, the low pressure engine would, as stated, either be doing nothing or be pulled round by the other two engines; that is to say, the low pressure engine would be either useless, or injurious as acting with a retarding effect on the other engines. This drawback would be much felt by our war-ships because of the nature of their duties, but would not be detrimental to the ocean mail steamers, which are nearly always worked at full power. Now, as the dragging round of a useless engine by the other two, causes a waste of coal, and

as the coal endurance is injuriously affected thereby, can some means be devised whereby the useless engines could be quickly and simply disconnected, and leave the work to be done by the others? A plan is proposed for cutting off one of the engines which it is considered, for the reasons given in the chapter, should be the smallest, the high pressure engine. If this be done several results will follow, as, *e.g.*, the steam pressure acting on the larger areas of the intermediate and low pressure cylinders, the power of the two engines thus compounded would more nearly approximate to the full power of the three. It is estimated that a 21 knots ship, full power, would, by the suggested compounding of the two larger cylinders, be able to easily steam at any rate of speed up to 16 or 17 knots, which would be all that could be wanted for ordinary service. Another result would be that at lower rates of speed the engine-power could be obtained with the use of a reduced boiler steam pressure, which would greatly tend to the preservation of the boilers by the reduction of the strain to which they would be otherwise subjected. Attention is directed to the concluding remarks of this chapter, made to meet the objection that it is retrogressing to go back from the triple expansion to the compound type. "When the principle of the expansion of the steam would be *fully carried* out in the suggested compound engines, no benefit, but positive injury, would be caused by adding another engine."

It will be well here to add a few remarks to the chapter on this subject. As a matter of detail, if the two larger cylinders be compounded, as suggested, by

the disconnection of the high pressure engine, it would be desirable that the stop-valve in the branch steam-pipe of this engine should not only be very strong, in an equally strong box, but that the valve itself should be capable of being *locked* when in the *shut* position. If this be not done some stupid fellow might open the valve in mistake for some other, and the consequences would be serious. As a distinguished flag-officer under whom I was serving some years ago, once said to me, somewhat cynically, "Make your written directions for the government of the action of officers of the squadron as full and simple as possible, for it is more necessary to legislate for foolish than for wise men." So in this matter of the disconnection of the high pressure engine, it should be made in such a way that even "fools" may not be able to do any damage by mismanagement.

It is possible that many may say, that the high pressure being the smallest engine, the disconnection of it would make so little difference as to make it not worth while to cut it off. I am aware that the disconnection of the low pressure engine would, in this one respect, be better, because the work of moving the larger and heavier piston would in that case be saved; but on the whole, and for the reasons stated, it is considered that the high pressure engine should be that to be disconnected. Whether, however, the high or the low pressure engine be disconnected would not affect the proposition, which is, that at low rates of speed one engine of a set of these triple expansion engines should be disconnected, so as to save the other two engines the work of pulling it round when useless.

There is no doubt that if some simple arrangement could be fitted, whereby one of a set of triple expansion engines could be easily and quickly disconnected, the two remaining, being worked as compound engines, it would be a great advantage when working at low and moderate rates of speed; it would prevent coal being burned for doing useless work, *i.e.*, would improve the coal endurance, in these days a matter of the greatest importance, and which might, in the time of trial, possibly determine great issues, by the lengthening of the time a war-ship could keep the sea, and perform efficient service.

In concluding the consideration of the points discussed connected with ships and machinery, it may be useful to very briefly review the naval work of the past six years.

If it be true, that the closest approximation to the perfect ship of war, is that in which each and every part is up to an equally high degree of efficiency, it is pleasant to record that considerable progress, generally speaking, has been made in the direction of producing perfect war-ships.

In illustration of this, two classes of ships might be instanced, the 1st and 2nd classes of unarmoured cruisers, of which the *Edgar* and *Sirius* are respectively the types. The success of these appears to be phenomenal. The *Edgar* is built of steel; has a displacement of 7,350 tons; is fitted with double screw triple expansion engines, capable of developing a maximum power of 12,000 horses; is 360 feet long, and 60 feet beam; has a coal stowage of 850 tons, and is

estimated to steam with that coal, at a speed of 10 knots, a distance of 10,000 knots. Her armament is :—

2.—9·2 inch, 22 ton, breech-loading guns.*			
10.—6 inch quick-firing			,,
16.—6 pounder quick-firing			,,
3.—3	,,	,,	,,
8.—Machine		,,	,,

On actual trial, the *Edgar*, with a maximum engine-power of 12,550 horses, realised a speed of 20·97 knots, or, in round numbers, 21 knots. Moreover, this power and speed was obtained with a limited forced draught, represented by an air pressure of less than $\frac{3}{4}$ inch ; that is to say, under absolutely safe conditions, as regards the boilers. When these particulars are considered, it must be admitted, that in respect of the chief elements of *offensive* power, viz., size, armament, speed, and coal endurance, the *Edgar* class are magnificent ships of war, and probably have no equals, and certainly no superiors, in the similar class of ships in foreign navies.

It is true that these and similar ships are weak in *defensive* power, as to the hulls, etc., but ships, like all human institutions, never can and never will be quite perfect; some sacrifice has to be made in order to develop the special points, and ensure fitness for the performance of the particular kind of service, for which the several classes of ships are designed. Of the protected cruisers, however, it must be said, that the vital parts of the ships are protected by a steel deck, and

* Lord Brassey's Annual, 1890.

thus the defensive power has, as far as possible, been provided for.

Similarly the *Sirius* class, the 2nd class unarmoured protected cruisers, are very efficient war-ships, of 3,600 tons; 9,000 horse-power; 20 knots speed; 400 tons coal stowage, and a coal endurance of 8,000 knots. The armament of the 2nd class cruisers is also, relatively, as powerful as that of the 1st class. Several vessels of the 2nd class cruiser class have recently gone through their full power trials with exceptionally favourable results, developing rather more than the maximum contract full power, viz., 9,000 horse-power, and attaining a speed of over 20 knots, with a limited forced draught that put a strain on the boilers, which they could safely bear.

Also as to many of the battle-ships, especially the most modern ones, great offensive and defensive power are combined with a speed and engine-power, that should make them most formidable portable floating batteries, able alike to give and receive the "hard knocks" that assuredly will be given and received in future naval battles.

It must be admitted that the *Sharpshooter* class of vessels have not been successful in many respects, having failed in every case, to attain the speed in knots, and develop the engine-power, viz., 4,500, for which they were designed; moreover, it is very questionable whether they are good sea-boats.

It must also be said that some serious failures of the boilers of several ships have occurred, as, *e.g.*, the *Thunderer*, *Blake*, *Vulcan*, and some others. These

have been dealt with elsewhere, but it may be added, that these boilers are of faulty design; that the faults are well known, and that, therefore, in future boiler designs, it will be easy to avoid the errors.

With regard to these shortcomings, it may be said, that if it be true that we learn more from failures than from successes, it is probable that the experience gained will be most valuable, and will result in success in future.

On the whole, there is no doubt that there has been recently a great advance made in designing and building both ships and machinery, and that our modern war-ships are more nearly perfect than were those of only a few years ago.

But as the effective service of every ship of war depends on the competence of the departmental complements to utilise and develop all its power as an engine of war, it may be hoped that efficient complements, in respect of both number and quality, will be drafted to all war-ships on commissioning,* not, as was well said by Mr. John Penn, such complements as, in a time of peace, will enable ships to go pottering along at a slow rate of speed; but complements that will make our powerful war-ships equal to the performance of any and every kind of duty that may be required of them in actual war service.

* See Page 208, Chap. II., Part IV.

IX.

Naval Engineering in War Ships. Chapter I. Page 131.

THIS chapter aims at giving unprofessional men a more correct view of naval engineering science than exists at present. The professors of this science can be judged only by a knowledge of what they know and do, and especially taking into account their heavy responsibilities in the charge of the costly machinery now fitted in modern war-ships. These responsibilities are twofold, viz., (1st) the preservation of the machinery from loss of value by deterioration, and (2nd) the enormous importance of the steam machinery, considered in the light of being the sole motive power of the ship. In former days it was not the sole—it was not even the chief—motive power in the ship. Then the steam-power was frequently wanted only to take the vessel in and out of port, and steam through calms. In this chapter it is urged that all executive officers should have a more thorough knowledge of the principles on which are based the design and construction of modern steam machinery. It is the want of this knowledge that makes it difficult for many to have a correct idea of the difference between engine-driving and engineering. The difference between these two is explained at length. The question also is answered, "Why should it be necessary to have highly-trained engineer officers in our war-ships?" and the discussion of this question proves that on no account should there be any lowering of the standard of qualification. What constitutes good

naval engineering? and what should be the chief aims of all good naval engineer officers? These are defined and remarked on in the order of their importance, as—

1. The condition of the machinery.
2. The treatment of the machinery when being worked.

It must be remarked here, that the driving of our modern naval machinery to the best advantage requires a considerable amount of skill, which can be developed and increased by experience and practice, and therefore it is of great importance; but it is of secondary importance to the maintenance of the machinery in that excellent *condition* which alone can enable those working it to drive it to the utmost advantage. This matter will be dealt with elsewhere, but meanwhile it is mentioned here because some may demur to the opinion that the driving of modern machinery is considered of secondary importance to the work of keeping it in an efficient condition.

There is no doubt that there are many who hold the view that *engine-driving* is the beginning and the end of naval engineering. They are mostly those who, being non-professional men, know little or nothing of modern naval engineering, or those who are professionals, but whose lack of experience with, and knowledge of, modern machinery, cause them to be unable to form opinions on the subject worthy of respect. But this view that engine-driving is synonymous with engineering is most erroneous. This is dealt with elsewhere,* but it is re-

* *Vide* Page 133, Chap. I., Part III.

ferred to here because it is pertinent to the subject-matter of this chapter on Naval Engineering. We therefore pass from this, and proceed to remark, that in this chapter an illustration is given of the way in which a want of *condition* in one single respect in the boilers and engines will injuriously affect the efficiency of a ship of war, and more especially as regards the duration of the sea-going efficiency of that ship; and thence it is argued, that it is of enormous importance that the maintenance of the machinery in an efficient condition should be the chief aim of all naval engineer officers.

Also as to the management of the machinery when being worked under steam: It is shown what would be the difference in the action of a mere engine-driver and of an engineer, and in what way this would affect efficiency.

In order to show the difference between good and bad engineering, a case is supposed of two of our largest first-class cruisers, of the same type, size, tonnage, engine-power, and coal stowage. These steam a distance of 4,500 knots together, and the results are worked out, it being pre-supposed that in the one case is exhibited good, and in the other bad, engineering.

It may be mentioned here that the case of these two large cruisers is frequently quoted and referred to in the course of the four chapters on the subject of Naval Engineering, because they afford a good illustration of the several points raised for consideration.

The argument in this chapter is directed towards proving that it is essential that in our ships of war we should have the highest engineering talent we can get,

and that it would be fatal to efficiency if the engine-power were controlled and managed by an inferior class of men.

It may be added here, that if it be considered necessary or expedient, either for the sake of economy or for any other reason, to cut down the number, or lower the quality of the staff of the various departments in our war-ships, surely the engine-room department should be the last in which the experiment should be tried, for on this department alone depends the success or failure of our fleets as sea-going ships of war. Take the most recent case, the *Royal Sovereign:* This ship will probably cost more than £750,000—three-quarters of a million of pounds. Her massive propelling engines are duplicated, and there are in addition more than seventy steam engines, some of which are in almost every part of the ship. Nearly everything done in this ship is done by the steam and other machinery. Without it the ship is useless as a man-of-war. The machinery is the life and soul of the ship, and this being so, the failure, or even the loss of this costly ship, worth three-quarters of a million of pounds, and immeasurably more to the country in a time of war, might conceivably be caused by an inefficient or insufficient engine-room departmental staff. Then how suicidal to send weak engine-room staffs on board our war-ships !* How important that this department should have a strong staff, both in respect of number and quality. We end as we began: The engine-room department in

* See on this subject the chapter on Engine-room Complements, Part IV., Chap. II.

every war-ship should be the last in which should be tried the experiment of economising either in men or money.

X.

Naval Engineering in War-ships.
Chapter II.
Page 145.

HERE an endeavour is made to prove, that the efficiency of the machinery is inseparably connected with economy in the consumption of coal. Economy is, in fact, a measure of efficiency. This is fully dealt with, and, in illustration, the cases of the two first-class cruisers cited in the last chapter is further referred to, and results worked out, with a view to showing how the coal endurance is affected. But the principal matter dealt with in this chapter is the consideration of the question, whether it is possible for the staff of the engineer department in every ship to keep the boilers and machinery, generally speaking, during a commission, in an efficient condition, without any assistance from dockyards, except the supply of material for repairs. In the discussion of this question the circumstances under which all ships are commissioned are fully considered, and especially as regards two special points, viz., (1st) the ships, and (2nd) the staff of men sent to every ship on commissioning. The conclusion arrived at is, that it should be practicable during a commission for a ship's staff to keep the machinery in thoroughly good order, without assistance from dockyards, provided that an efficient engine-room staff be drafted to the ship on commissioning, and that time and opportunity be given for necessary examination

and repairs. This last point is dwelt on at some length, because it is an essential element in the successful accomplishment of the great work to be done.

Connected with this subject another most important question arises, viz., "Is there any means by which the mechanic ratings could be improved, and with no expense, made more fit to carry out the great work of maintaining the efficiency of the machinery of the ships in which they serve, during a commission, without assistance from dockyards?" This question is considered from several points of view, and answered by the suggestion that the Steam Reserves should be utilised in the carrying out of this work; and the way in which it might be done, and the facilities for doing it, are fully dealt with.

The chapter finishes by the remark that the carrying out of the proposed plan would enable the Steam Reserves to draft a more able class of mechanic ratings to ships on commissioning, and thus make it easier for the fleet men to make their vessels entirely self-supporting during commission.

XI.

Naval Engineering in War-ships. Chapter III. Page 160.

It would be well if some method were adopted to ensure regularity of action, and prompt attention to small defects before they grow into big ones, and in this chapter a definite plan is formulated in detail, by which every member of the departmental staff would be enabled to do a part of the whole work of maintaining the efficiency of the ship's

machinery. The engine-room staff of a modern warship is taken in illustration of the proposed plan. The principle on which the plan is based is the assignment of the various parts to the members of the staff for special care and oversight. Two tabular statements are given marked (I.) which gives the allocation of the parts to be cared for, and (II.) the full engine-room complement. Reasons are given why the adoption of the plan would not affect discipline, except to improve it. Result of the adoption of the plan after it had been in operation a sufficient time to have its full effect would be, "the improvement of the engine-room staff in every ship, by increasing their ability and confidence, making them more careful in management, and quicker in detecting and making good small defects before they became big ones; it would create a spirit of emulation among the whole of the members of the steam branch of the Navy, and, above all, would exorcise the spirit of helplessness which is induced by the knowledge that every little defect that arises can be turned over to and be made good by the dockyards."

Possible objections on the part of some of the engineer officers are remarked on, and met by the question whether there is any easy and simple way in which the ability and zeal of some, as compared with others, may be differentiated, with a view to rewarding the most deserving. This question is answered by expanding the proposition that "Economy is a true measure of efficiency."

XII.

Naval Engineering in War-ships. Chapter IV. Page 178.

THE Home Station Steam Reserves are considered as schools of instruction for the improvement of the fleet mechanic ratings in ability to do a higher class of machinery repairs than that ordinarily done, and thus make them more fit to carry on the work of maintaining, unassisted, the efficiency of the machinery of the ships to which they are drafted, and in which they will serve for a commission. All the circumstances in connection with the plan and *personnel* of the Steam Reserves are detailed, with the result that, at the present time, they are, without any alteration, quite fit to carry on the work of training the mechanics of the fleet in the higher class of repairing work.

Two things are wanted, viz. :—

1st. The allocation of the necessary work hitherto done by dockyards, and

2nd. The entry of 180 additional engine-room artificers exclusively for training in the Steam Reserve workshops, *i.e.*, 60 in each of the three Steam Reserves.

The kinds of work now done by the fleet mechanics are described, and the description proves that scarcely any work of an improving kind is now done to keep these men up to fleet requirements.

The expense caused by the entry of 180 additional engine-room artificers is considered, and it is shown how this expense to a great degree will be met.

It may be added, before passing from this subject, that not only should 180 engine-room artificers be immediately entered for the purposes stated, but, what is of great importance, the number entered annually should be increased in order that there shall be, *at all times*, in each Reserve, not fewer than 60 of these men set apart for employment in the Steam Reserve workshops, for the improvement of their mechanical ability. These men should be on the permament staff for not less than one year, nor more than two years, and during their period of training should not be considered available for doing any of the ordinary work of the Reserves, except as stated in the chapter. This is very important. It is evident that the entry of 180 additional men at present, and then a reversion to the normal number at present entered would not suffice for the requirements.

The chapter then takes up the subject of naval engineering generally, and the question considered is; How far can the amount of work done by the engine-room staff of every ship during a commission be measured, *i.e.*, work done in maintaining the efficiency of the machinery without outside assistance? for if this can be done, there will be a ready means of placing on record the services of the most successful and deserving engineer officers, with a view to their obtaining official recognition and reward.

The chapter concludes with a quotation from one of the Service journals, remarking on the great and important duties connected with naval engineering.

A few remarks on the general subject of engineering

may now be added, before passing away from it, to the consideration of other matters.

It has been said, that many people hold very erroneous views on the subject of naval engineering. This has been dealt with in the first chapter, and it is hoped that that chapter proves that in our ships of war there should be at all times one or more highly-trained engineer officers—not engine-drivers, but *trained engineers.* Assuming the correctness of this proposition, we may at once go on to comment on the erroneous opinions on this subject already referred to. A great many people cannot get away from the idea that engine-driving is neither more nor less than engineering, whereas instructed people know that the driving is only a part of engineering. This may be shown thus :—

A good engineer should know how

1. To design engines.
2. To make engines.
3. To drive engines.

Thus it will be seen that driving engines is only a part of engineering, and that not the most important part. It is admitted that driving the machinery—which of course includes the management of boilers as well as engines—of a modern ship of war is a very important operation, and requires a great amount of skill, and, it may be added, of experience. The management of boilers alone requires a nerve, courage,. and skill, which can only be acquired by experience; and the same may be said of the engines, and therefore no disparagement of the excellent work done by men who are chiefly en-

gaged in driving machinery is intended by these remarks; but it is repeated that this is only a part, and that not the most important part, of engineering. There are probably many most excellent drivers and managers of marine engines who could neither design nor make them. On the other hand, there are very few, perhaps not any, designers and makers of engines, who could not, with a little practice, efficiently drive them.

Thus, it is hoped, that it will be seen how erroneous are the views of those who hold that engine-driving is the same as engineering. To prove that this is the opinion of many people with a deservedly high reputation as regards naval matters generally, we may instance Lord Brassey, some of whose views are no doubt very sound, and who has done good work for the Navy generally, by the publication of his most excellent Annual. But on this subject he holds the perhaps commonly received opinion that engine-driving is engineering, for he appears to advocate the sending of our young engineer officers for a year to serve in one of our large Atlantic liners, as if the ability to drive engines were the beginning and the end of naval engineering.

This matter cannot be better illustrated than by quoting a story recently told in one of our leading Service journals.

A gentlemen was visiting one of our great ship and engine building firms in the North, and went over a large ship of war, which was being built for the British Navy. It was approaching completion, and the visitor was struck with the enormous amount and complexity

of the steam machinery in this ship, and he could not help ruminating on the kind of men who would hereafter have to control, manage, and be responsible for the great number of all sorts and descriptions of engines with which this immense floating battery appeared to be full. Apparently he could come to no satisfactory conclusion on the matter, for he interviewed the local manager of the firm, a man of great experience and eminence as an engineer. The visitor said to him:

"I have just been over the ship you have nearly finished for the Navy, and was struck with the vast amount of machinery in her. I suppose that there are many of the engineers in, and now running, the large merchant steamers you have built, who would be quite up to the mark of managing the machinery of that war-ship?" To which the manager replied:

"We have in our ships many very excellent men who manage their machinery capitally, but there are none I could recommend *for this job;* the man for this must have had a special training and experience to make him fit in all respects for the management of the machinery of this great war-ship."

This was the opinion of a man well qualified to judge, not associated in any way with the Naval Service, and therefore not biased at all in favour of naval engineer officers. And who can doubt but that this opinion was a thoroughly sound one,—an opinion that deserves to have great weight should the question of reducing the number of competent engineer officers serving in our ships of war, ever arise for the consideration of those who have the administration of the Navy in their hands?

Another erroneous opinion as to naval engineering, which appears to be held by many is, that the only thing necessary in the engineering of war-ships is to steam them on their cruises and from port to port: that this is more or less a mechanical operation, which can be done by the fleet mechanics; and that therefore there is no absolute necessity for the supervision exercised by highly-trained engineer officers. This has been dealt with in the first chapter on the subject of Naval Engineering, but a few remarks may be added to show how erroneous this idea is. As has been shown, the maintenance of the efficiency of all the complex machinery of a war-ship, so that it might always be worked to the utmost advantage, is the first, and much the more important, duty of a naval engineer; and the working or driving these engines to the utmost advantage is of comparatively less—though still of great—importance. Many people, through not understanding this, hold the erroneous opinion that supervision by highly-trained engineer officers is not necessary, and the wildest theories on this matter have been broached and talked of. It is rumoured that it has even been suggested by some, that the executive officers might do the supervising engineer duties, leaving to the mechanic staff of the steam department the task of carrying on the practical duties of that department.* On this point the opinion of the manager in the story related on page 271 might be quoted. "We have in our large ships excellent men, who manage their machinery capitally, but there are none I could recommend for this job,"—

* *Pall Mall Gazette*, April 29th, 1892. *Engineering*, June 17th, 1892.

the charge of the machinery of a large ship of war—"the man for this *must* have had a special training and experience." This is the thing in a nutshell: "*A special training and experience.*" How long, it may be asked, does it take to give an engineer who devotes his attention exclusively to this subject this necessary training and experience? I answer with some confidence, that it takes *one-third* of a professional lifetime. If this be true, how utterly futile it seems to be to suppose it possible for an executive officer, occupied, as he has been in the study of other subjects, to be ever equal to the efficient performance of the duties of supervising the steam department of a large war-ship. The only thing that can be said of this matter is, that the formation of so erroneous an opinion is caused by a simple ignorance of the requirements of modern naval engineering; and that is why it would be well for our executive officers to have a greater knowledge than at present of the subject.

In studying such a science as that of engineering, it requires some knowledge of it before one can realise how very much there is to learn in order that its elements should be thoroughly grasped and understood. "A little knowledge is a dangerous thing"; and therefore there is little doubt that it would be well if our executive officers had a greater knowledge than at present of naval engineering. A part of the speech of Admiral Hoskins to the Cadets in the *Britannia* will bear repetition here:—"With reference to a knowledge of steam, it was apparent that such a knowledge was a great necessity in the Service. The sails which used

to be their motive power, were now *things of the past*, and . . . our young officers should have a full knowledge of their new motive power."

Of this it may be remarked that while the possession of this knowledge would not, of course, make officers competent to take charge of, and efficiently supervise the steam department of a war-ship, it would, once for all, prevent the formation and expression of such extraordinary, and it may be added, such unwise opinions as have been advanced on this subject from time to time in the past.

It is hoped that these remarks, together with those in the first chapter on Naval Engineering, will do somewhat towards dispelling all erroneous opinions held by many on this subject, and will result in a higher appreciation by all non-professional men of the nature and importance of the duties performed by the superintending engineer of every war-ship, the efficient service of which depends on the way in which this officer administers his department. It must be remembered that he who controls and manages the steam department of a large war-ship must not merely be a figure-head, but a really competent, experienced, well-trained engineer; and it is contended that no officials of a lower qualification will suffice for the requirements of the war service of our fleets, especially in the time of stress and danger. This is a matter vital to the continuous efficiency of our sea-going war fleets, and there should be no paltering with it to suit the views of any who may hold extreme opinions. In any case, no great alteration of the present system should be made, until the whole matter receives

full consideration by those who are competent, by their knowledge of the subject, to judge of the effect that any change of importance would have on the general efficiency of the Navy.

XIII.

Miscellaneous.
The Coal Endurance of Her Majesty's Ships.
Page 193.

A REFERENCE is made to the naval manœuvres, which called public attention to the subject of the coal endurance of our ships. The mode of calculating the coal endurance at present is described, and the causes of inaccuracy pointed out. This method has resulted in the coal endurance being over-estimated.

A definite plan is proposed, whereby the coal endurance of *single ships* might be calculated with absolute accuracy, because it would be ascertained by actual experiment at sea. It is recommended that this be done in the case of every ship newly commissioned, sometime early in the commission, and the result recorded as part of the history of the ship. This information would be useful to the Captains of our ships, and the Admirals commanding fleets and squadrons, for it would tell them in every case how long their ships would remain efficient at sea, so far as the coal stowage was concerned.

The second part of this chapter considers the coal endurance of sea-going fleets and squadrons. This is important because it determines the duration of the efficiency of fleets at sea acting in combination. The present practice is remarked upon, and it is pointed out, that it acts prejudicially on the war strength of sea-going fleets.

The whole subject is thoroughly discussed in the chapter, and as the present system is faulty, there are four separate plans proposed, by the adoption of one or more of which the coal supply of sea-going fleets might be kept up, so as to enable them to keep the sea for months, instead of for days as at present. Two of the plans in combination are preferred, and reasons are given.

The effect of the operation of the two plans is described, one effect being that it would be no longer necessary to provide armed convoys for colliers in war time. The question of expense is considered, and the chapter finishes by asking two questions, the answers to which will determine whether it would be for the benefit of the Naval Service to adopt the plans proposed and formulated.

XIV.

Miscellaneous.
The Engine-room Complement of Her Majesty's Ships.
Page 208.

In this chapter the late reduction of the number and the lowering of the quality of the engine-room complements of our war-ships are considered. A paragraph is quoted from the *Times*, in which the alteration is announced, an announcement which has been since verified by subsequent events.

This alteration of the complements is considered in view of the greatly increased amount, value, and importance of the steam and other machinery now fitted in modern war-ships, as compared with former days. It is pointed out that this change will probably impair the efficiency, and also increase the cost, of sea-going

fleets. This may appear paradoxical, but it is true. Its effect on efficiency is first discussed, and it is pointed out that every engine-room complement has to perform two distinct kinds of duties, which are clearly defined, and of which one is more important than the other. Therefore the complement should be assigned on the principle, that the staff of the ships should be equal to the performance of the more important of these two kinds of duties. If this be acted on, the staff competent to do the superior work will also be able to do the inferior work, but the converse is not true. The staff which could do the inferior would probably not be able to do the superior work. Now, the alteration made recently appears to be made on the assumption that the so-called inferior work is the chief, indeed, the only, work necessary to be done. The staff that will be sufficient for this will be sufficient for all else that may be required. The fallacy of this is shown by the matter being discussed at length, and it seems to prove that the efficiency of the machinery of our war-ships will be seriously impaired by the change.

As to economy: There will be an annual saving in respect of the payment of the lower, who are substituted for the higher, class men; but this will result in the end, for reasons which are given, in a very serious pecuniary loss.

Two reasons are given why the engine-room complements of war-ships should be strengthened rather than weakened, and it is submitted that these deserve serious consideration.

The chapter finishes by directing attention to the

fact that our mastless floating batteries are wholly dependent on the steam service of the ships, and an appeal is made to the authorities to decide that it will be for the best interests of the Navy, to draft strong engine-room complements, rather than weak ones, to all sea-going ships of war.

This subject seems to call for a few additional remarks. It will be seen that an endeavour has been made to prove that engine-driving is not engineering, and it would appear that there are some eminent men who are of the same opinion. Mr. John Penn, the head of the great engine-building firm, in a letter to the *Times* of the 18th June, 1892, makes some weighty remarks on the subject. He says:

"There is, no doubt, a widespread belief that the work in the engine-room department simply consists of driving the engines. This is a serious mistake.

"Let me state how the change of complements would work in the case of the *Royal Sovereign*. The original complement of the *Royal Sovereign* consisted of one chief engineer, five engineers, and eighteen engine-room artificers. The reduced complement consists of one chief engineer, six engineers, and twelve engine-room artificers. Upon these nineteen men devolves the duty of keeping in order the main propelling engines, the seventy-eight other engines, and all the vast and complicated mechanical appliances throughout the vessel . . . . this staff is insufficient for the purpose.

"The fact is, Sir, that we have been so long at peace that the powers that be do not recognise the enormous

strain that would be put upon the staff of the ships in time of war.

"The present Board of Admiralty have done good work. . . . . I appeal to them to reconsider a decision"—to reduce the engine-room complements—"which, if ruthlessly carried out, may land us in something like national disaster."

Mr. Penn speaks in his letter with the authority of a man who is the head of a firm which has justly had, for more than fifty years, the reputation of being one of the greatest engine-building firms in the country.

In this connection it might be well to compare the complement carried by the *Royal Sovereign* with that carried by one of the largest Atlantic liners, the *Teutonic.* The war-ship carries nineteen skilled men, *i.e.*, mechanics; the *Teutonic* carries twenty. In the battleship the *Royal Sovereign*, there are, besides the propelling engines, seventy-eight other engines, and, as Mr. Penn says, "all the vast and complicated mechanical appliances throughout the ship."

Not only so, but other conditions differ in favour of the merchant-ship, and against the war-ship. The *Teutonic*, on arrival at Liverpool, has a "shore gang" ready to receive her, and to give their assistance in making good all defects that may have been developed on the voyage. The *Royal Sovereign* has no "shore gang." Her defects either must be made good on board by the ship's staff—which could be easily done with a staff of sufficient strength—or she must find her way from time to time to the nearest dockyard, which, conceivably, might be impossible in a time of war.

Considering these things, does not weakening the engine-room complements of our ships of war appear to be absolutely foolish? and not the less so that there can be no possible reason why it should be done, except, perhaps, the desire to save a few thousands of pounds a year, which might be required if a sufficient number of mechanic ratings were kept in our Reserves,* from which might be drafted strong numerical mechanical complements to all ships when commissioned.

It was well said in the letter already quoted that small engine-room complements may be sufficient to keep ships pottering along at low powers and speeds, but it will be a very different thing in times of emergency, when, for an indefinite period, ships may be called upon to do their best. At such times the tactical skill of Captains and the courage of the men on deck will go for little, if the orders transmitted below are not carried out promptly by a large staff of competent men, alert, vigorous, and fresh. "Captains of ships cannot be expected to take their ships into action with the requisite nerve if they feel that their engine-room staffs are incapacitated by overwork and worry, and that the machinery of their ships is not in the highest state of efficiency."

Finally, this question of the engine-room complements may be expected to influence that part of the labour market, from which we get our supplies of mechanic ratings for the service of the fleet. With engine-room complements of the necessary number and quality to prevent "overwork and worry," there is no reason

* See Naval Engineering, Chap. IV.

why we should not get for the Naval Service, the cream of the mechanics in the country, of whom large entries would probably have to be made, in case of war being declared, which would, of course, necessitate the commissioning a large number of ships.

XV.

Miscellaneous.
Electric Lighting and other Subjects.
Page 220.

NEW inventions and systems should be tried in every way, but especially by the experimental test, before adoption in the Naval Service—There are drawbacks, even in good and beneficial inventions; hence caution is necessary—This view is illustrated in the case of electric lighting our ships—Remarks on steam steering, propelling, distilling, air compressing, and mooring and unmooring machinery—Considered at some length, resulting in the decision that in every case, when it can be easily done, the duplication of all parts vital to the efficient service of ships should be carried out—Should engineer officers be made executive officers? —Arguments for and against—Result: Neither necessary nor expedient—Conclusion.

It will be seen by the foregoing Summary that several changes in the present practice have been suggested, with a view to meeting the requirements and improving the efficiency of our future Navy. These changes may be briefly stated in order as follows :—

1. The training of 12,000 men of the stoker class into skilled gunners, and so to increase the fighting power of the Navy.

2. The training of both stokers and seamen, from the time they are entered as boys, in general service, as "all-round" men, to fit them for the duties pertaining to modern seamanship.

3. Limitation of the strain put on the boilers of war-ships, so that they may be capable of being worked under absolutely safe conditions.

4. Conversion of triple expansion engines into pairs of compound engines, with ease and rapidity, to prevent loss when working at low rates of speed, and so to improve the coal endurance.

5. The improvement of the mechanical ability of all fleet mechanic ratings, to make them more competent to carry out the great work of maintaining the efficiency of the machinery of every ship during commission, without any assistance from dockyards, excepting the supplies of material.

6. In carrying out the work of maintaining the efficiency of the fleet by fleet officers and men some methodical system is necessary.

7. There should be some method of placing on record the service of all engineer officers in carrying out this work, with a view to differentiating the ability of some as compared with others, and rewarding the most deserving.

8. There should be some way of easily and accurately measuring the efficiency of all ships during a commission.

9. The Home Steam Reserves should be strengthened, and certain means adopted, whereby the improvement of fleet mechanic ratings might be effected for the reasons stated in 5.

10. It would be well to have some plan, whereby the amount and description of the work done during a commission in maintaining efficiency, by the fleet officers and men, might be placed on record.

11. There should be some method of ascertaining accurately the coal endurance of: (*a*) single ships of war, (*b*) fleets and squadrons of sea-going ships.

12. Cannot some method be proposed, whereby the coal endurance of squadrons and fleets may be improved in such a way, as to enable them to keep the sea for months, instead of days, as at present?

13. The principle on which should be based the assignment of engine-room complements.

And, besides the thirteen points enumerated, there are others of a minor character which are not mentioned here, because their adoption does not involve any considerable departure from the present practice. But as regards the thirteen changes suggested, their adoption will necessitate more or less change of this kind, and in order that there might not be any misunderstanding as to the means to be used for effecting these changes and

improvements, a plan, in nearly every case, has been formulated and submitted for consideration.

Now, before these points are further considered, it may be well to remember what has been so frequently referred to in the foregoing pages, viz., that our present Navy is altogether different to that of the past; indeed, it is so unlike the past Navy, that several of our most distinguished and experienced officers have stated, with more or less emphasis, that the present Navy requires for its efficient service an entirely new seamanship, a "modern seamanship," as unlike the old seamanship as the present Navy is unlike that of the past. The distinguished men who have expressed this opinion are ardent lovers of the old seamanship; and it is with something more than regret, it is almost with pain, that they have come to the conclusion, that, in the interests of the present and future Steam Navy of England, it is necessary that there shall be *some changes* in the present practice and procedure, in order that the requirements of modern seamanship might be fully met. Circumstances in connection with the naval changes which have taken place during the past forty years have been too strong even for the most conservative of our best naval officers, who are consequently giving up, one by one, and with the greatest reluctance, many of the usages of the past as regards the old seamanship.

In connection with the changes suggested in this book three questions might be asked:—

1. Are any changes necessary?

2. If changes are necessary, what should they be?

3. What will be the best means of carrying into effect these necessary changes?

As to 1: If no change is necessary, all that can be said is, that no harm can be done by considering contingencies that may arise, and we must make the best of the present systems.

As to 2: If changes are called for, what should they be? Are any of those suggested some of them? If so, which are they?

As to 3: Are the means suggested the best for effecting these necessary changes?

Some answers to these questions may be found in the arguments advanced in this book, remembering that the "path of wisdom is rather to look forward than backward. . . . . we must resign ourselves to giving up the old seamanship;" also, that no "attempt should be made to put back the hands of the clock." . . . . and that it is necessary . . . . "to step forward to meet the change, which, however unpalatable, is *inevitable*."*

* Vice-Admiral Sir Edmund Robert Fremantle on "The Training of Our Seamen." Lecture before the Royal United Service Institution: *Journal*, March, 1892.

CONCLUSION.

IT is hoped that the contents of this book will impress on the minds of readers, especially non-professional readers, the great importance of naval engineering science, as one of the chief elements in the successful war service of our sea-going fleets; and, following from this, the urgent necessity of always having on board our war-ships some highly-trained, experienced *specialist* engineer officers to carry out the duties pertaining to this naval engineering.

A modern ship of war is a wonderful structure, made up of an infinite number and variety of parts, which, by the genius of our naval architects, are so well balanced as to enable the ship to perform, with safety and efficiency, effective fleet service of all kinds, but especially war service. But of what use is this modern ship of war without the steam and other machinery? With the machinery *not* in operation the ship is inert, useless; it can go nowhere and do nothing. With the machinery *in* operation she becomes at once instinct with LIFE, MOTION, POWER. The machinery propels the ship, steers the ship, and lights the ship: by its assistance the guns are fought, and an immense deal of work of many kinds done, which heretofore has been done by tedious and costly manual labour. There is, indeed, some analogy

between men and ships. The machinery is, in some respects, to the ship, what the mind and intelligence are to man. Therefore the science of engineering is a very important one, and is becoming more important every day. Considering it as a whole, and not only one part of it, it may be said that there can be no end to the study of it. No perfect engineer has ever lived, or ever will live; for the most advanced student, after a lifetime of study, would probably say that there was still a vast amount for him to learn.

Many parts of this book, which deal with matters more or less technical, have been written, not so much for professional as for non-professional men; for the general public, who are interested in the Navy; and for those officers of the Services whose knowledge of the subject is limited, because of their having to devote most of their time and attention to matters more immediately connected with the special branches of the Service to which they belong.

It is not expected that the writer's views will meet with universal concurrence and approval. There will, doubtless, be very many and great differences of opinion, both as to the ends in view, and as to the means whereby those ends are proposed to be gained. But there is one respect in which there will certainly be perfect unanimity, and that is that the Steam Navy of England must at all times be a strong Navy. One of our Admirals* is reported to have recently said on this subject that "England's best Foreign Minister is a strong Navy." Like most epigrams, this is full of

* Admiral of the Fleet Sir J. E. Commerell, G.C.B.

sound sense and deep meaning. Opinions on international questions, especially in troublous times, gain immense force because of the possession of great national power by the country which, by its statesmen, expresses those opinions; and this power, in the case of such a nation as England, should operate directly and beneficially in the preservation of peace.

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This book is now submitted in the hope that it will, to some extent, and in a humble way, contribute to the promotion of the efficiency of the future Steam Navy of England. If so great a Service as Her Majesty's Navy should, in any degree, be benefited, the author's end will be gained. He has spent a long professional life-time in that Service; and in its advancement, prestige, and fame, he will never cease to take the greatest interest while life lasts.

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